Data Book

BRIMAR

RADIO VALVES & TELETUBES

Standard Telephones and Cables Limited

FOOTSCRAY - KENT - ENGLAND

BRIMAR

RECEIVING VALVE

6AM6

APPLICATION REPORT VAD/508.2

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

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INTRODUCTION: The Brimar valve type 6AM6 is a miniature indirectly heated high slope RF pentode. The heater is intended for operation in parallel with other valves in AC operated equipment. The valve is designed for use as an RF or IF amplifier, suitable shielding and short leads provide a good performance in high frequency circuits. This report contains characteristics of the valve and details of its performance as a wide band amplifier, resistance capacity coupled amplifier, video amplifier and as a frequency changer.

DESCRIPTION: The valve consists of a miniature RF pentode having a mutual conductance of the order of 7·5 mA/V and is mounted in a standard T5½ bulb and fitted with a B7G standard base.

CHARACTERISTICS:

Cathode:	Indirectly heated	
	Voltage	6·3 volts
	Current (nominal)	0·3 ampere
	Max. DC Heater-Cathode potential	150 volts
Dimensions:	Max. Overall Length	2-1/8 ins.
	Max. Diameter	3/4 in.
	Max. Seated Height (excluding tip)	1-19/32 ins.
Base:	Type B7G	
Basing Connections:	Pin 1 Control Grid g_1	
	Pin 2 Cathode	
	Pin 3 Heater	
	Pin 4 Heater	
	Pin 5 Anode	
	Pin 6 Suppressor Grid g_3 and Shield	
	Pin 7 Screen Grid g_2	

Ratings (Absolute Values):

PENTODE CONNECTION:

Max. Anode Voltage	300* volts	550† volts
Max. Screen Voltage	300* volts	450† volts
Max. Anode Dissipation	3·0 watts	
Max. Screen Dissipation	0·9 watt	
Max. Grid 1 Circuit Resistance	100,000 ohms (fixed bias)	
Max. Grid 1 Circuit Resistance	500,000 ohms (auto bias)	
* At I_a 10 mA.	† At I_a 0 mA.	

TRIODE CONNECTION (Pins 5 and 7 strapped, Pin 6 strapped to Pin 2):

Max. Anode Voltage	250 volts
Max. Anode Dissipation	3·3 watts
Max. Cathode Current	30 mA
Max. DC Control Grid Current	1 mA

Capacities (approx.):*

PENTODE CONNECTED:

c in.	7·5 pF
c out.	3·2 pF
c_{g1a}	0·005 pF†

TRIODE CONNECTED:

c in.	5·1 pF
c out.	5·3 pF
c_{ga}	2·7 pF

* Measured with close fitting shield connected to cathode.

† The value quoted is the rated capacity as measured with all holder capacitance balanced out: the maximum value is 0·0075 pF. The figures quoted will be increased by from 0·0001 to 0·00025 pF, depending upon the design of the holder used.

GROUNDED GRID OPERATION:

$c_{a,k}$	0·2 pF
c in.	8·6 pF
c out.	3·1 pF

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

Anode current plotted against control grid voltage for various screen voltages (I_a/V_{g1}) (Curve No. 308·2).

Anode current and screen current against suppressor grid voltage for various screen voltages V_{g1} = 0 (Curve No. 308·3), V_{g1} = —1·5 (Curve No. 308·4) and V_{g1} = —3 (Curve No. 308·5).

Mutual conductance and anode impedance against control grid voltage (g_m/V_{g1}) (r_a/V_{g1}) (Curve No. 308·48).

Anode current plotted against anode voltage (I_a/V_a) for a screen voltage of 300 volts (Curve No. 308·212), 250 volts (Curve No. 308·49) and for 200 volts (Curve No. 308·201).

Anode current plotted against anode voltage (I_a/V_a) connected as a triode (Curve No. 308·6).

TYPICAL OPERATION

Class A Amplifier:

PENTODE CONNECTED (g_3 connected to cathode):

Heater Voltage	6·3	6·3	6·3	volts
Anode Voltage	200	250	300	volts
Screen Voltage	200	250	300	volts
Grid Voltage	—1·5	—2	—3	volts
Cathode Bias Resistor	130	160	300	ohms
Anode Current	9·0	10·0	8·0	mA
Screen Current	2·25	2·5	2·0	mA
Anode Impedance (r_a)	0·5	0·9	1·2	megohms
Mutual Conductance (g_m)	7·5	7·5	6·75	mA/V
Inner Amplification Factor (μ_{g1g2})	70	70	70	
Grid Voltage for 1/100 g_m at V_{g1} = —1·5, —2 and —3 respectively	—4·8	—5·8	—6·9	volts
Suppressor Grid Voltage for 1/100 g_m at V_{g3} = 0	—51	—66	—85	volts
Equivalent Noise Resistance (R_{eq})	1000	1100	1000	ohms
Input Impedance at 45 Mc/s	7000	8200	9500	ohms
Input Impedance at 90 Mc/s	—	1200	1350	ohms

TRIODE CONNECTED:*

Heater Voltage	6·3	volts
Anode Voltage	250	volts
Grid Voltage	—2	volts
Amplification Factor	75	
Anode Impedance	10,000	ohms
Mutual Conductance	7·5	mA/V
Anode Current	12·5	mA

* The suppressor grid (g_3) should be connected to the cathode: under no circumstances should it be connected to the anode.

Operation as an RF or IF Amplifier (narrow or wide band). The valve is very suitable for service in the above application. It is recommended that cathode bias always be used rather than fixed bias, and that normally, the suppressor grid (g_3) and the internal shield be connected to the cathode at the socket. When the screen voltage is lower than the anode voltage a potentiometer rather than a series resistor should be used to furnish this voltage.

In order to ensure high gain with stability, the valve socket should be so mounted that the grid and anode leads to the remainder of the circuit run in opposite directions to each other and are as short as is practicable. The decoupling components should also be chosen and located with care for similar reasons, the heater being decoupled with condensers and chokes when necessary.

When used in VHF or television receivers the valve may be employed with normal pentode connections or as a grounded grid amplifier at frequencies of the order of 100 Mc/s. It is also very efficient as an IF amplifier using intermediate frequencies around 10 Mc/s.

For those applications where very high frequencies are employed and changes in input capacity, and input impedance are undesirable, it is advised that grid bias be applied to the control grid and suppressor grid simultaneously, the control grid being biassed to a value of approximately 3·5% of that applied to the suppressor grid.

Curves are attached to this report as follows:

Input capacity, mutual conductance and input impedance plotted against control grid voltage at 50 Mc/s (Curve No. 308·7); similarly but for A.V.C. (Curve No. 308·8); input capacity, mutual conductance and input impedance against screen grid voltage (V_{g2}) at 50 Mc/s with auto bias (Curve No. 308·9). Input capacity, mutual conductance and input impedance against suppressor grid voltage (V_{g3}) at 50 Mc/s with control grid voltage V_{g1} = 3% of V_{g3} (Curve No. 308·10), V_{g1} = 4% (Curve No. 308·11) and V_{g1} = 6% (Curve No. 308·12). Curves Nos. 308·13, ·14, ·15, ·16, ·17 and ·18 are similar to the above but taken at a frequency of 90 Mc/s. Input impedance is plotted against control grid voltage for various values of unbypassed cathode resistor at a frequency of 45 Mc/s (Curve No. 308·206).

Operation as a Resistance-Capacity Coupled Amplifier:

PENTODE CONNECTED:

The valve is very suitable for use as RC coupled amplifier, and below is a table giving a summary of useful values for a distortion of approximately 5% harmonic:

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

Anode Load (R_a megohms)	0·1		0·22		0·47	
Series Screen Resistor (R_{g2} megohms)	0·27		0·47		1·1	1·3
Grid Leak (succeeding valve) (megohms)	0·22	0·47	0·22	0·47	0·47	1·0
Cathode Resistor (ohms)	470	470	1500	1500	2200	2200
Output Voltage (peak)	60	65	40	47	39	45
Voltage Gain	195	235	205	245	250	315

Curves are attached to this report showing the characteristics. when used under RC coupled amplifier conditions with an HT line voltage of 250 volts. Curve No. 308·202 is plotted with an anode load resistor of 470,000 ohms and shows the relation between anode current, screen current and control grid voltage for various screen voltages. Curves Nos. 308·203, 308·204 and 308·205 are similar to the above but plotted with anode load resistors of 220,000, 100,000 and 47,000 ohms respectively. The method of using these curves to design an RC coupled amplifier is described below.

If, for example, it is desired to use the valve with low distortion at a supply voltage ($V_{a(b)}$) of 250 volts with an anode load resistor of 220,000 ohms and a succeeding valve grid leak of 470,000 ohms, then an examination of the curve No. 308·203 shows that grid current (I_{g1}) commences at about —0·6 volts, hence a grid bias should be chosen such that the signal never swings the grid to a value of much less than —0·75 volt. If a value of about 1 volt is taken then fairly straight portions of the I_a/V_{g1} curves are available for V_{g2} = 60 volts. Taking the operating point as $V_{g2} = 60$ volts and $V_{g1} = -0{\cdot}9$ volt, the anode current will be 0·7 mA and the screen current I_{g2} 165 μA, hence the cathode resistor will be $\frac{0{\cdot}9 \times 1000}{0{\cdot}7 + 0{\cdot}165}$ or 1000 ohms. The screen dropping resistor would be $\frac{250 - 60}{0{\cdot}165 \times 1000}$ or 1·15 megohms.

If the grid has a peak AF input of 0·1 volt as a maximum, the anode current will vary from 0·92 mA at a grid voltage of —0·8 volt to 0·5 mA at 1·0 volt, hence a change of 0·42 mA in 220,000 ohms is 92 volts peak-peak. This is an output of 46 volts peak and a voltage gain $\frac{46}{0{\cdot}1}$ or 460.

As allowance must be made for the succeeding valve grid leak, the above values will be reduced by a factor of $\frac{470{,}000}{470{,}000 + 220{,}000}$ or 0·68, hence the actual operating gain will be 310 and the output voltage 31 volts peak for an input of 0·1 volt peak. An estimate of the distortion can be obtained by calculating in a similar manner the voltage gain for the positive swing 0·9 to 0·8 volt and the negative swing 0·9 to 1·0 volt separately the resultant figures indicating the amount by which one peak is amplified more than the other.

TRIODE CONNECTED:

The valve may be used as a triode RC coupled amplifier and a graph is attached to this report showing the relation between the various valve parameters under conditions of resistance coupling. This graph No. 308·211 is taken at an anode supply voltage ($V_{a(b)}$) of 250 volts with three values of anode load resistors, viz., 47,000, 100,000 and 220,000 ohms and plots the anode current, amplification factor, mutual conductance and anode impedance against grid voltage. From this graph the correct grid bias (cathode resistor) can be obtained, also 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, and anode load of 220,000 ohms and a succeeding valve grid leak of 470,000 ohms, then to determine the grid bias an inspection of the graph indicates a relatively linear portion of the curve of anode current/grid volts over the range of —1 to —4 volts, the mid point being —2·5 volts. At this point the anode current is 0·5 mA, hence the cathode resistance should be 500 ohms. The peak input voltage is 1·5 volts and the R.M.S. input 1·05 volts. Following the grid bias voltage upward on the curve it is evident that with an anode load of 220,000 ohms, the amplification factor (μ) is 55, and the anode impedance is 42,000 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 220,000 ohms in parallel with 470,000 ohms or is 150,000 ohms. The stage gain is:

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

or, in the above case:

$$\frac{55 \times 150{,}000}{150{,}000 + 42{,}000} = 43.$$

The peak input voltage above was 1·5 volts, hence the peak output voltage will be this figure multiplied by the stage gain or 65 volts, or 45 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 —1 volt is 53 and at —4 volts is 31, hence the distortion will be

$$\frac{53 - \left(\frac{53 + 31}{2}\right) \times 100}{53 + 31}$$

or 13%, which is rather high, indicating in this case that too big an input has been allowed.

Operation as an FM Limiter or Television Sync. Separator: The high slope and short grid base make the valve very suitable for use as a limiter for FM receivers or as a sync. separator. Operation data for these purposes can be obtained by reference to the Curves Nos. 308·202, ·203, ·204 and ·205 described under "Operation as a Resistance-Capacity Coupled Amplifier" on page 4.

Operation as an Oscillator: Due to the high slope the valve is very suitable for use as an oscillator, both connected as a pentode and as a triode, but the ratings given on page 2 should be observed. When used as an earthed anode or earthed control grid oscillator the heater should be maintained at the same RF potential as the cathode.

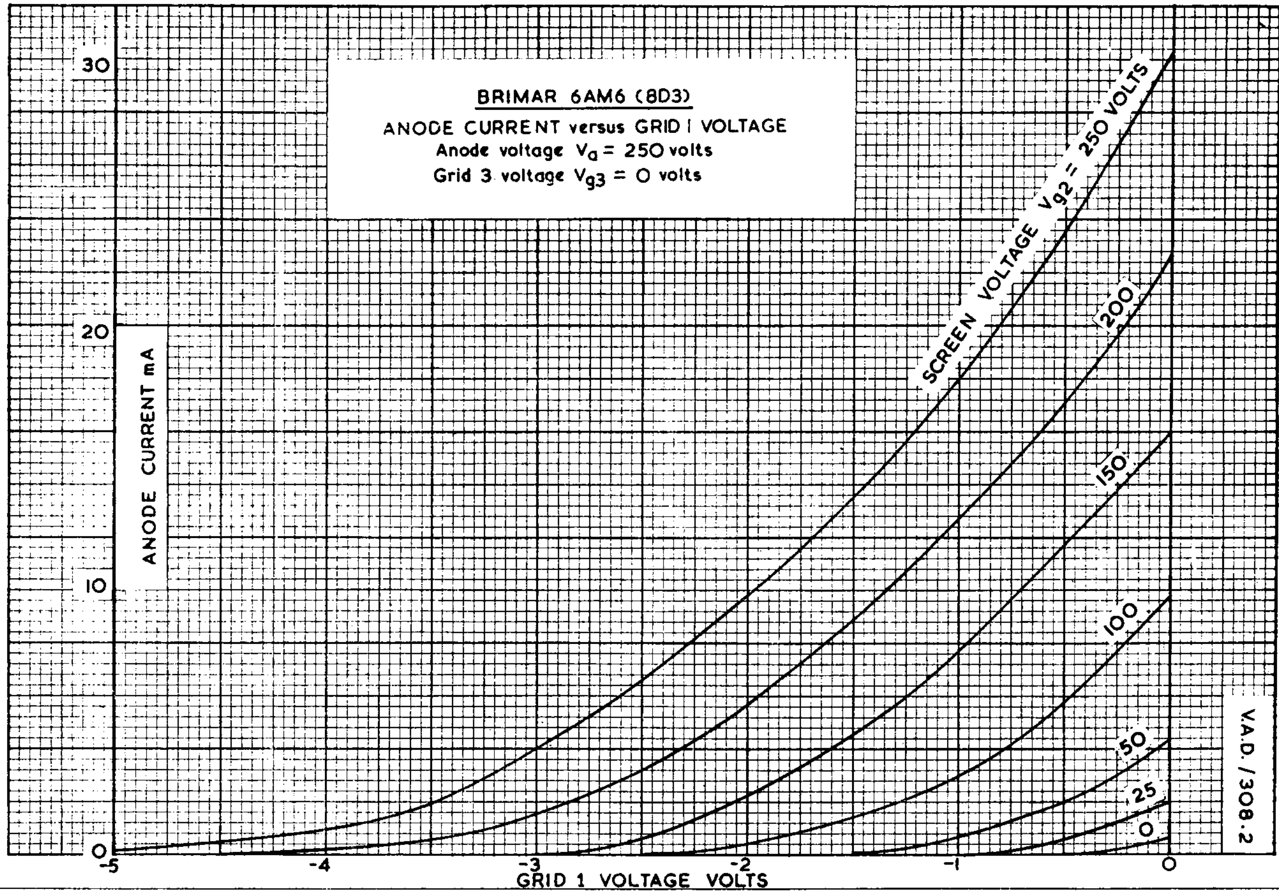
Operation as a Video Output Stage: The valve is very commonly employed as a wide band video amplifier in television receivers and curves are attached to this report showing this application. The curves plot the voltage gain against frequency with different values of output load capacity and different values of compensating inductance. When values of load are higher than those shown or the load capacity is higher more complicated compensation circuits will be required.

Curve No. 308·207 shows the voltage gain with three values of capacity 10, 15 and 20 pF for a load of 2·2K; Curves Nos. 308·208, 308·209 and 308·210 show corresponding curves for loads of 3·3, 4·7 and 6·8K. In the case of the latter the response cannot be compensated for a capacity of greater than 15 pF with a single inductance.

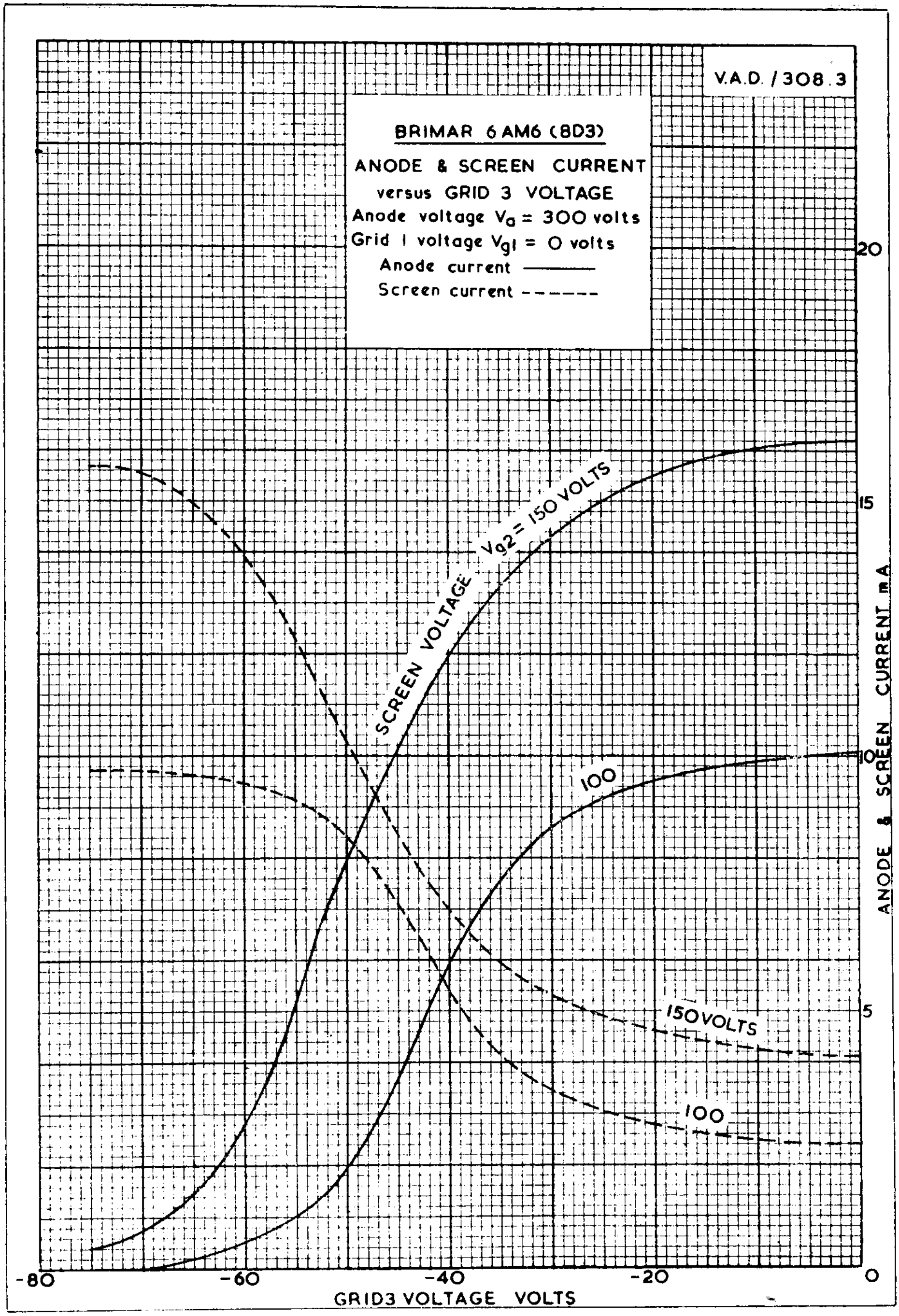
It is quite common practice when this valve is used as a video amplifier to obtain extra top lift by using a small value of cathode by-pass condenser or no condenser at all giving negative feed back at the lower frequencies, this practice will reduce the voltage gain shown in the curves by a factor of 0.47; for example, the voltage gain using no cathode by-pass condenser and 4·7K anode load will be about 14 at the low frequencies; the signal handling capacity will be unaltered.

Operation as a Frequency Changer: Due to the high slope of the valve and its short grid base, it may be very successfully employed as a frequency changer at frequencies up to about 150 Mc/s. It is recommended that grid or cathode injection be employed. The Curve No. 308·213 shows the conversion conductance, anode current and screen current plotted against peak heterodyne voltage. A typical circuit, such as would be employed in a superheterodyne television receiver, is also shown. Typical operating conditions are as follows:

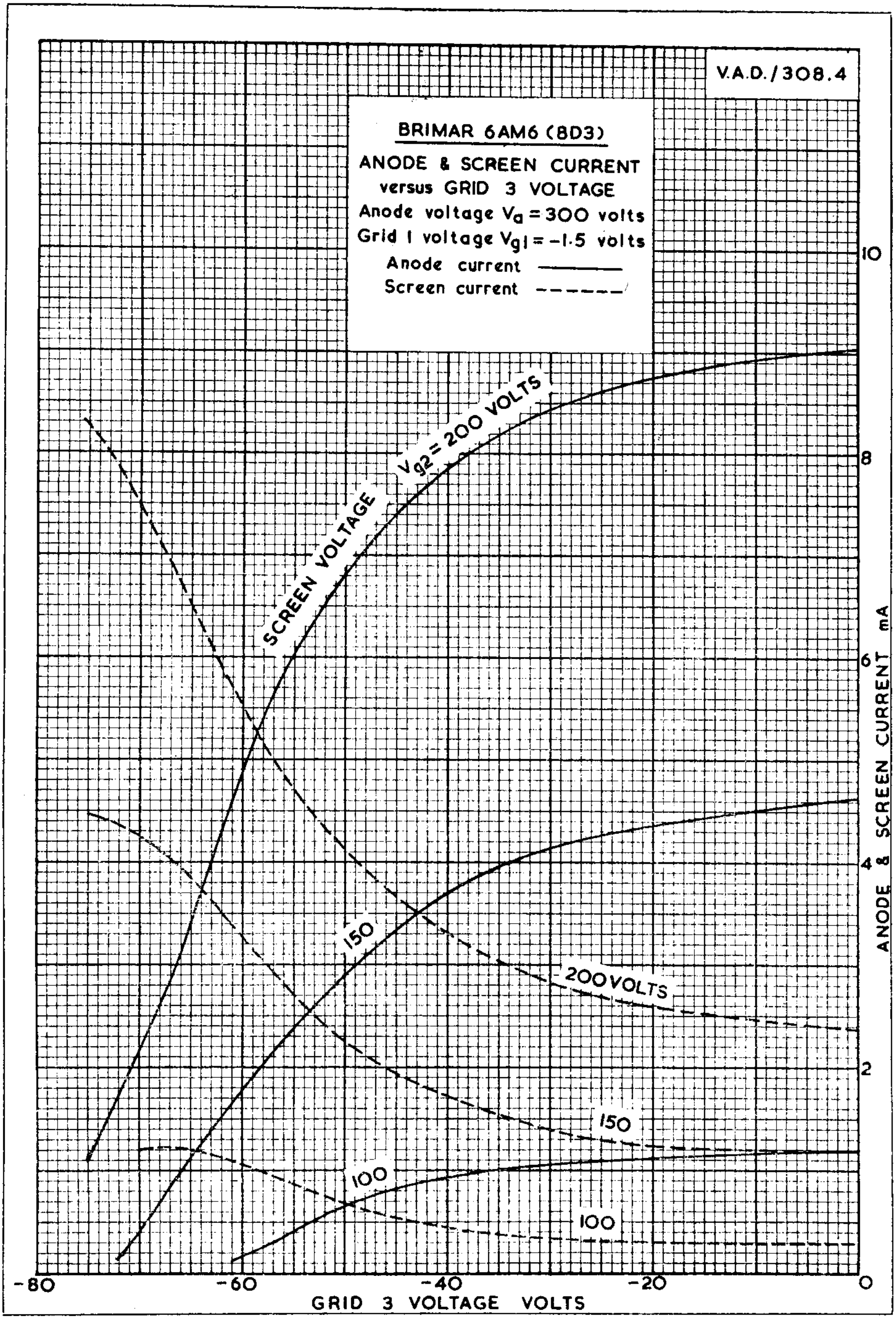
Anode Voltage	250 volts
Screen Voltage	250 volts
Autobias Resistor	1000 ohms
Anode Current	4·7 mA
Screen Current	1·2 mA
Peak Heterodyne Voltage	5 volts
Conversion Conductance	2·3 mA/V
Equivalent Noise Resistance	4500 ohms

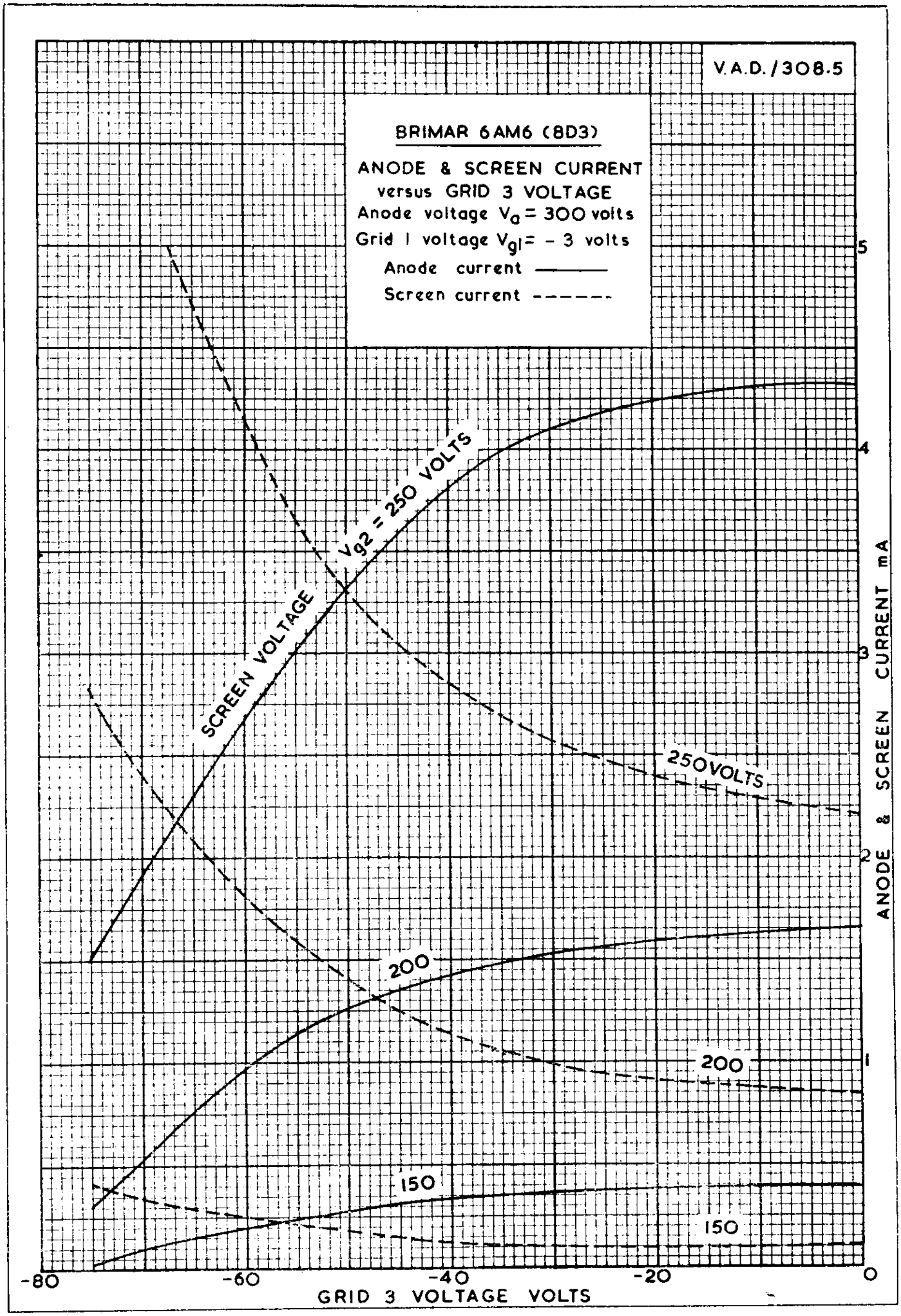


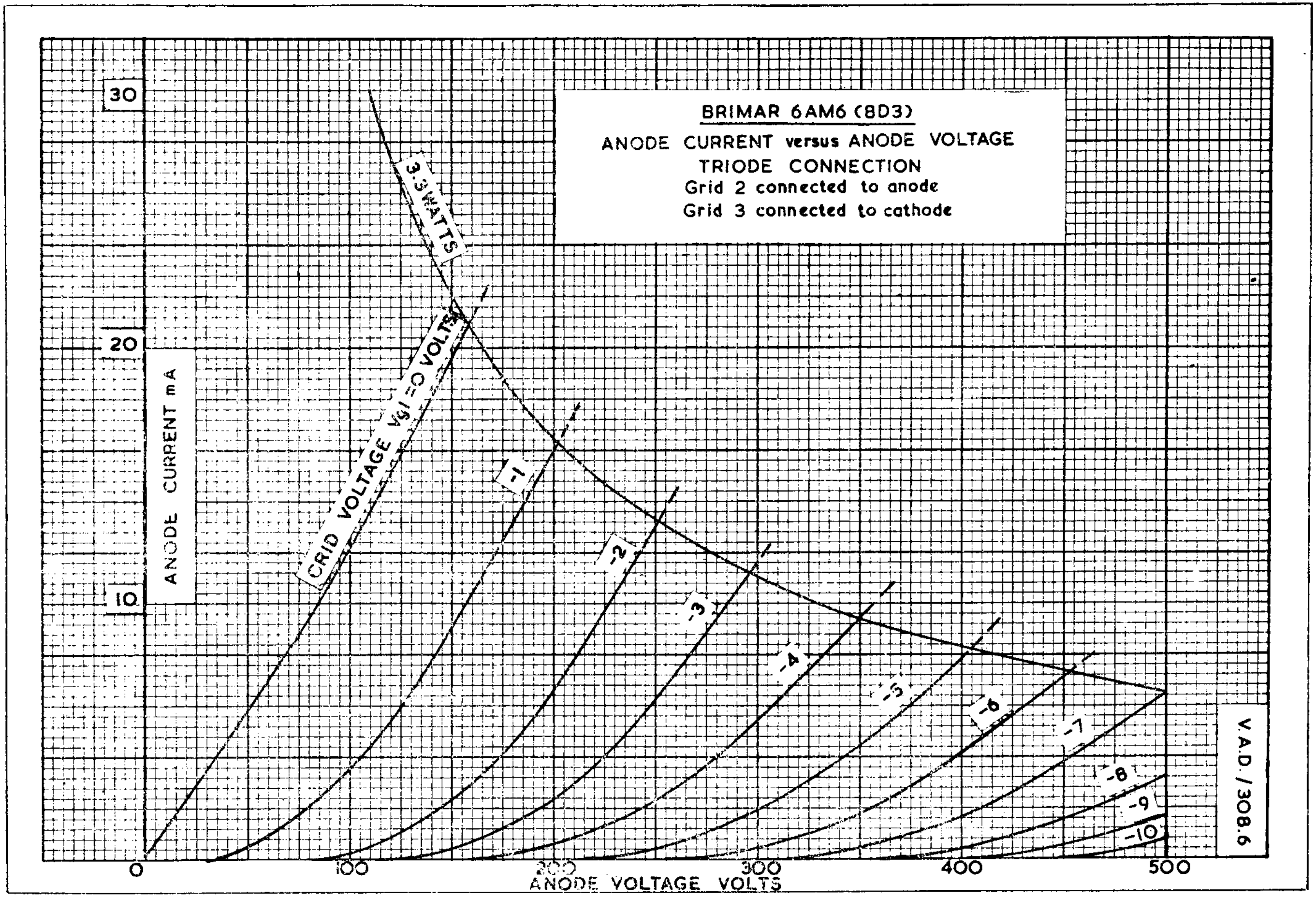
BRIMAR 6AM6 (8D3)
ANODE CURRENT versus GRID I VOLTAGE
Anode voltage V_a = 250 volts
Grid 3 voltage V_{g3} = 0 volts
SCREEN VOLTAGE V_{g2} = 250 VOLTS
200
150
100
50
25
0
ANODE CURRENT mA
30
20
10
0
-5
-4
-3
-2
-1
0
GRID 1 VOLTAGE VOLTS
V.A.D. / 308.2

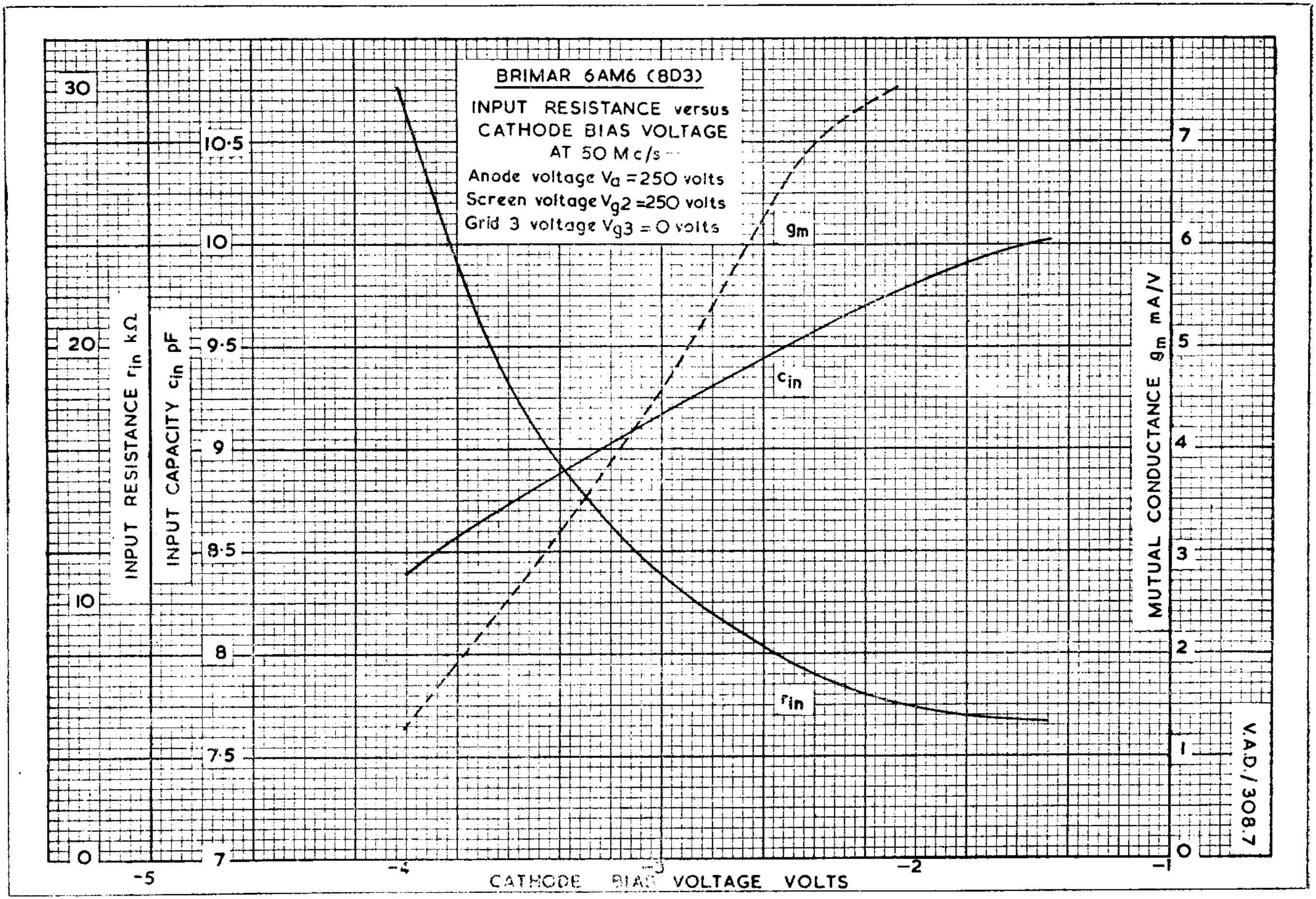


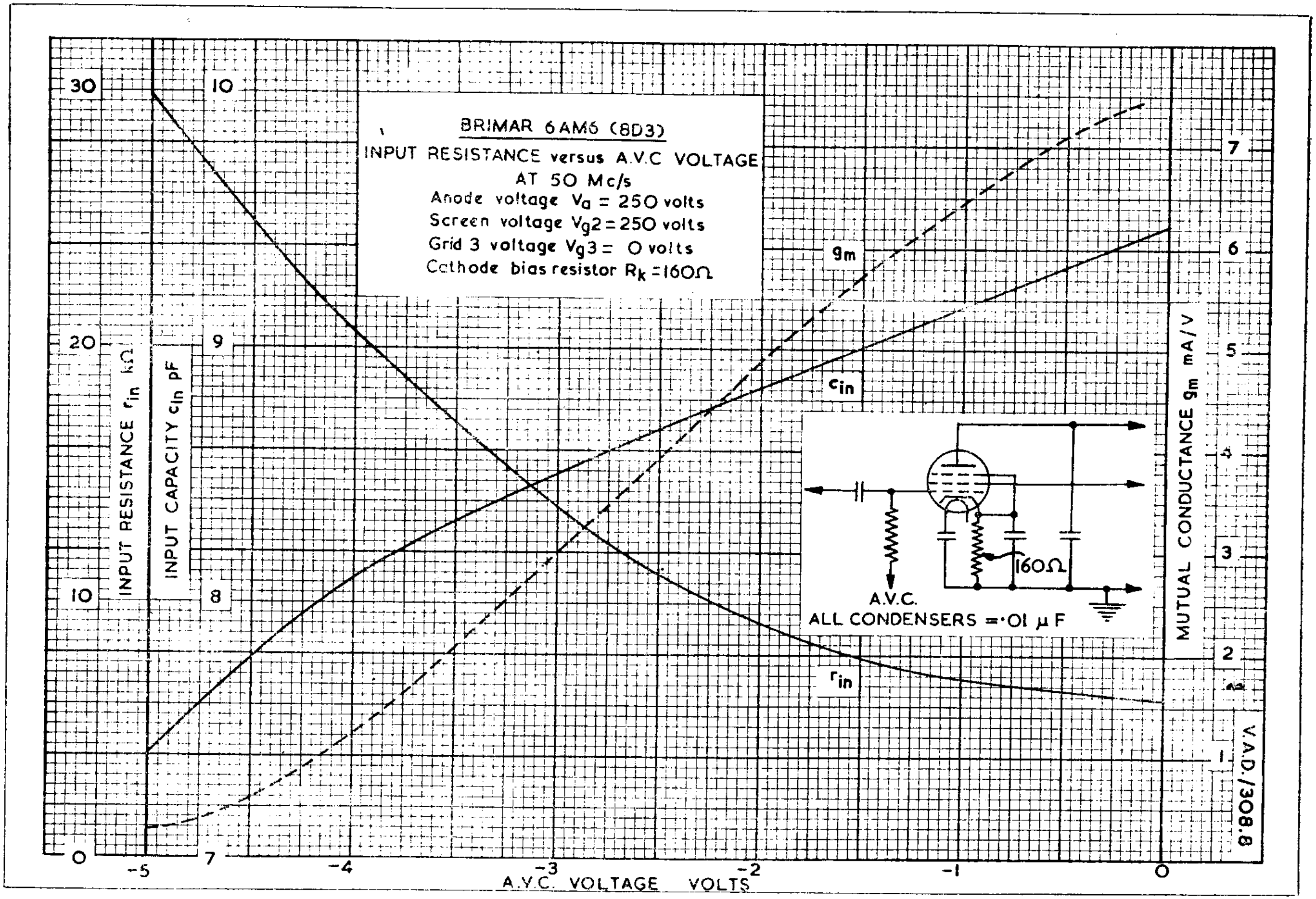
V.A.D. / 308.3
BRIMAR 6AM6 (8D3)
ANODE & SCREEN CURRENT
versus GRID 3 VOLTAGE
Anode voltage V_a = 300 volts
Grid 1 voltage V_{g1} = 0 volts
Anode current
Screen current
SCREEN VOLTAGE V_{g2} = 150 VOLTS
100
150 VOLTS
100
20
15
10
5
0
ANODE & SCREEN CURRENT mA
-80
-60
-40
-20
0
GRID3 VOLTAGE VOLTS

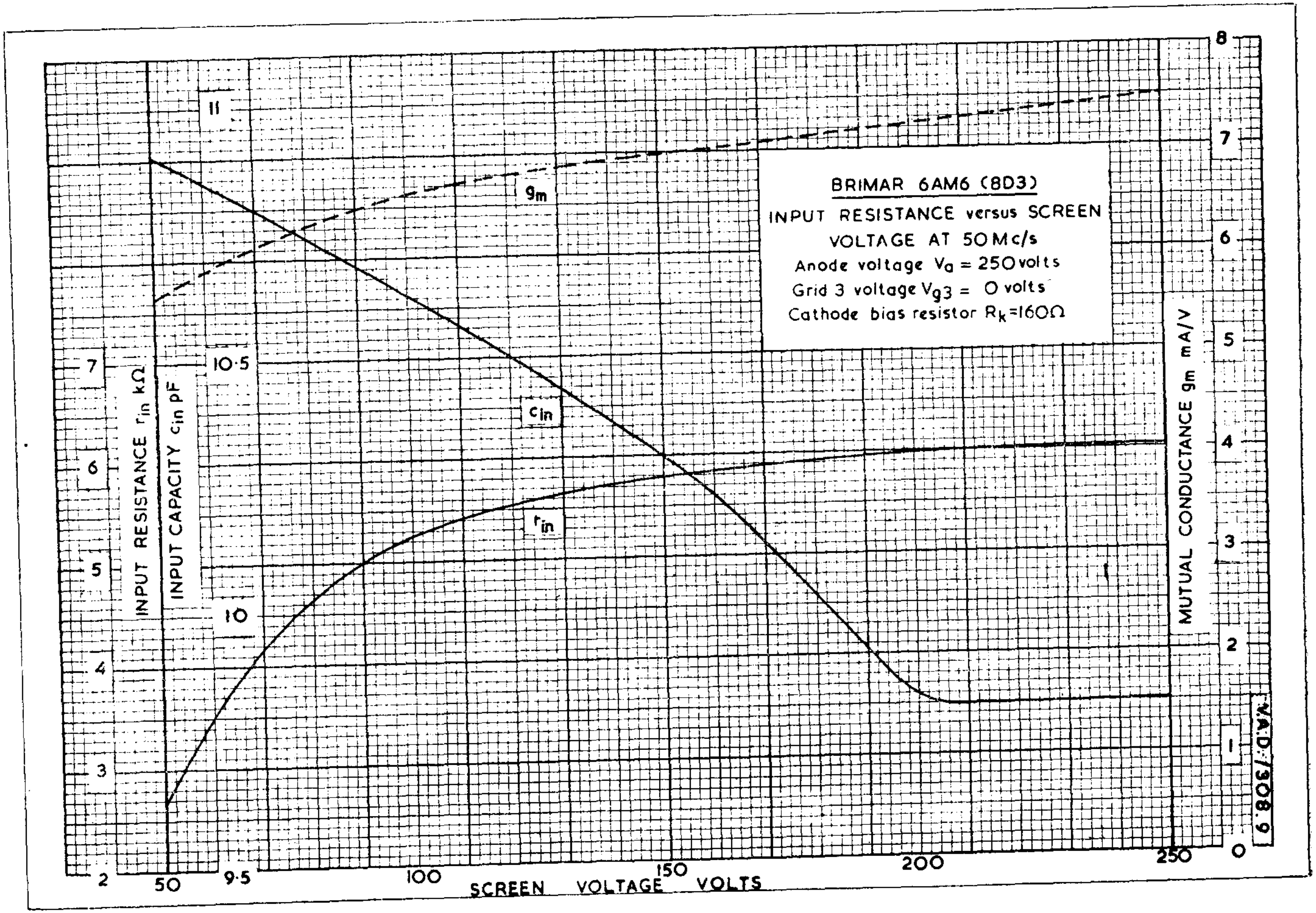

V.A.D./308.4
BRIMAR 6AM6 (8D3)
ANODE & SCREEN CURRENT
versus GRID 3 VOLTAGE
Anode voltage Va = 300 volts
Grid 1 voltage Vg1 = -1.5 volts
Anode current
Screen current
SCREEN VOLTAGE
Vg2 = 200 VOLTS
150
100
200 VOLTS
150
100
-80
-60
-40
-20
0
10
8
6
4
2
GRID 3 VOLTAGE VOLTS
ANODE & SCREEN CURRENT mA

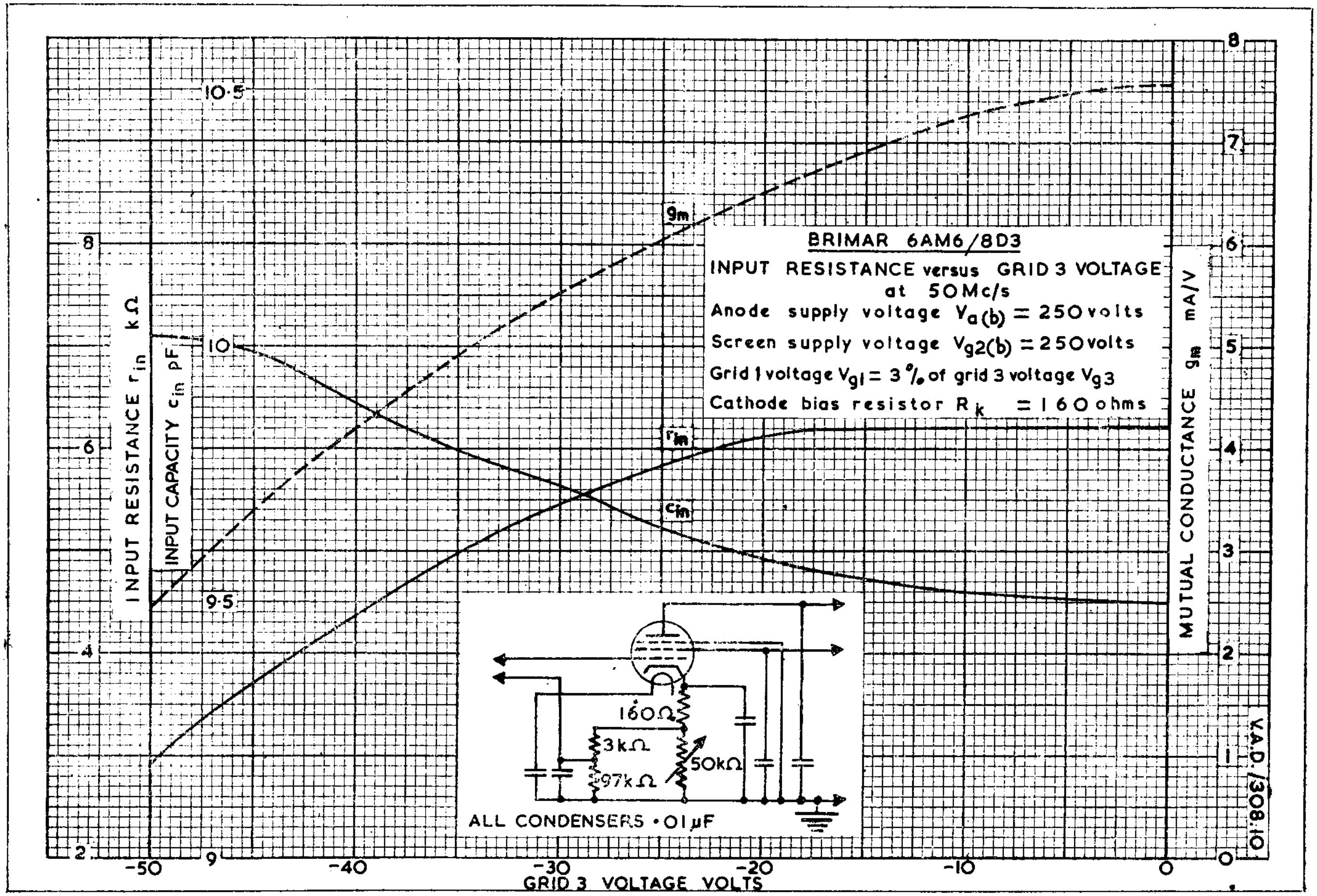

V.A.D./308.5
BRIMAR 6AM6 (8D3)
ANODE & SCREEN CURRENT
versus GRID 3 VOLTAGE
Anode voltage V_a = 300 volts
Grid 1 voltage V_{g1} = – 3 volts
Anode current ———
Screen current ------
SCREEN VOLTAGE
V_{g2} = 250 VOLTS
250 VOLTS
200
200
150
150
5
4
3
2
1
0
ANODE & SCREEN CURRENT mA
-80
-60
-40
-20
0
GRID 3 VOLTAGE VOLTS

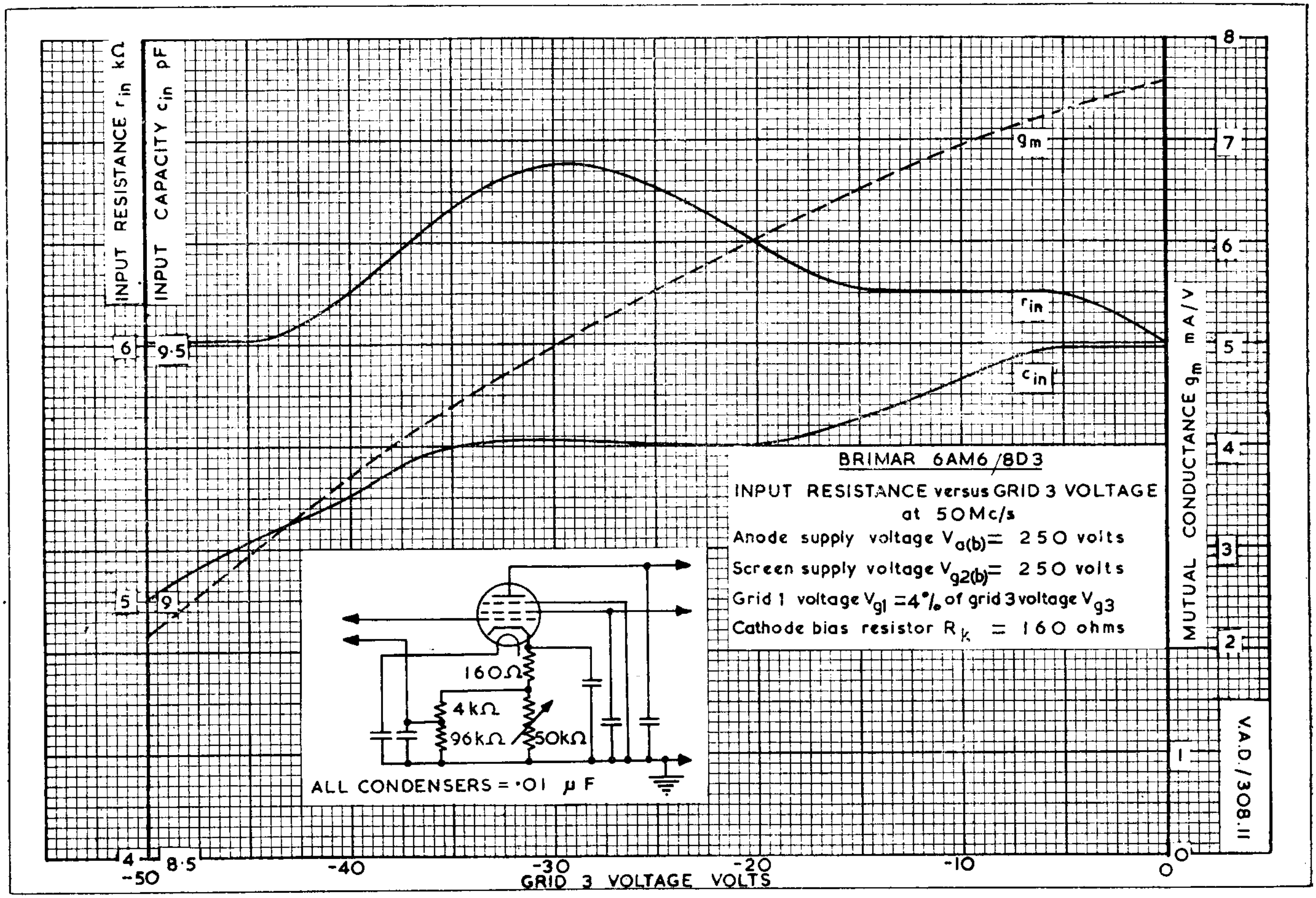

BRIMAR 6AM6 (8D3)
ANODE CURRENT versus ANODE VOLTAGE
TRIODE CONNECTION
Grid 2 connected to anode
Grid 3 connected to cathode
3.3 WATTS
GRID VOLTAGE Vg1 = 0 VOLTS
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
ANODE CURRENT mA
30
20
10
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
V.A.D. / 308.6


BRIMAR 6AM6 (8D3)
INPUT RESISTANCE versus CATHODE BIAS VOLTAGE AT 50 Mc/s
Anode voltage V_a = 250 volts
Screen voltage V_{g2} = 250 volts
Grid 3 voltage V_{g3} = 0 volts
g_m
c_{in}
r_{in}
INPUT RESISTANCE r_{in} kΩ
INPUT CAPACITY c_{in} pF
MUTUAL CONDUCTANCE g_m mA/V
CATHODE BIAS VOLTAGE VOLTS
30
20
10
0
10·5
10
9·5
9
8·5
8
7·5
7
7
6
5
4
3
2
1
0
-5
-4
-3
-2
-1
V.A.D./308.7

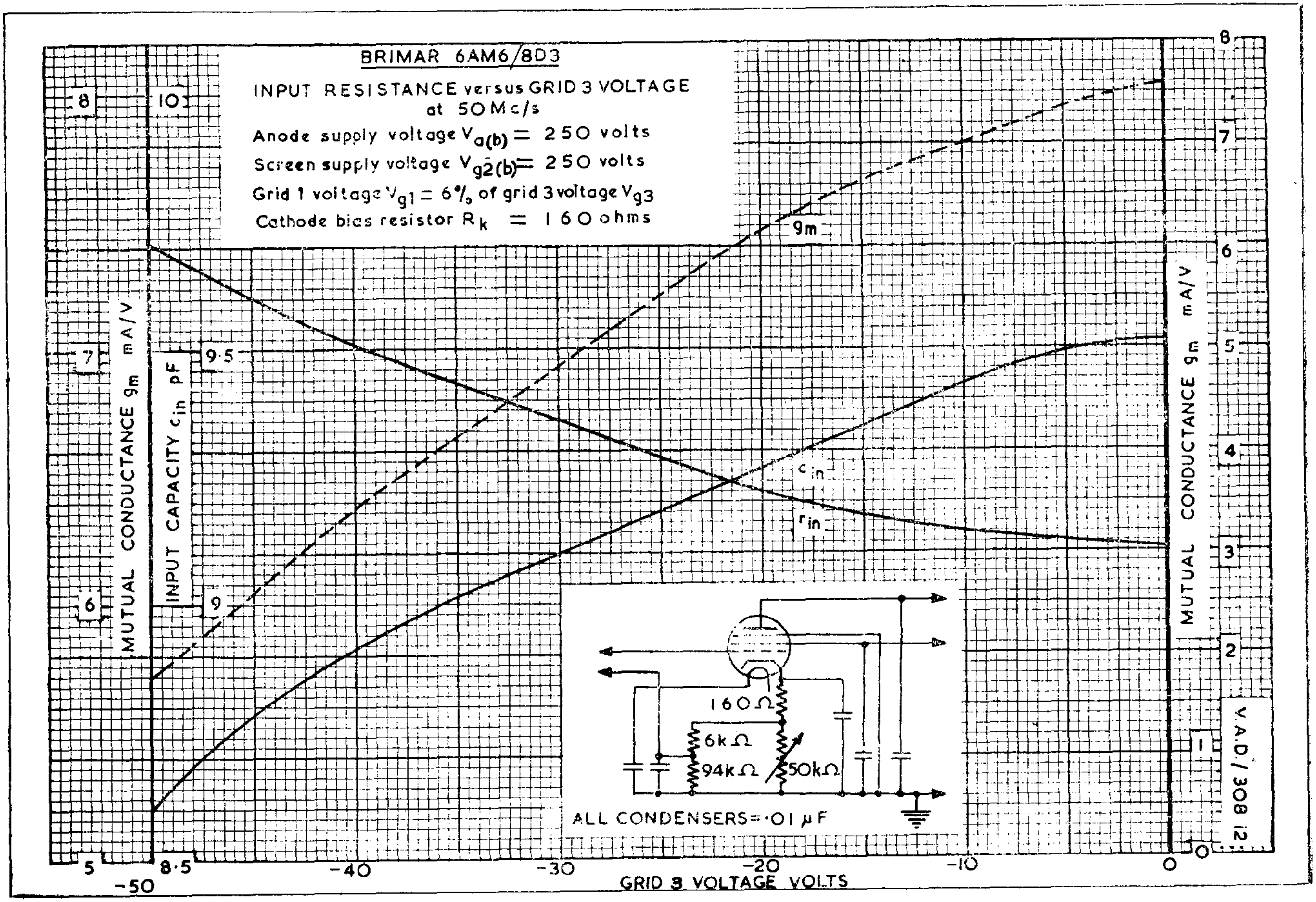

BRIMAR 6AM6 (8D3)
INPUT RESISTANCE versus A.V.C VOLTAGE
AT 50 Mc/s
Anode voltage V_a = 250 volts
Screen voltage V_{g2} = 250 volts
Grid 3 voltage V_{g3} = 0 volts
Cathode bias resistor R_k = 160Ω
INPUT RESISTANCE r_{in} kΩ
INPUT CAPACITY c_{in} pF
MUTUAL CONDUCTANCE g_m mA/V
A.V.C. VOLTAGE VOLTS
g_m
c_{in}
r_{in}
160Ω
A.V.C.
ALL CONDENSERS = ·01 μF
30
20
10
0
10
9
8
7
-5
-4
-3
-2
-1
0
1
2
3
5
6
7
V.A.D./308.8

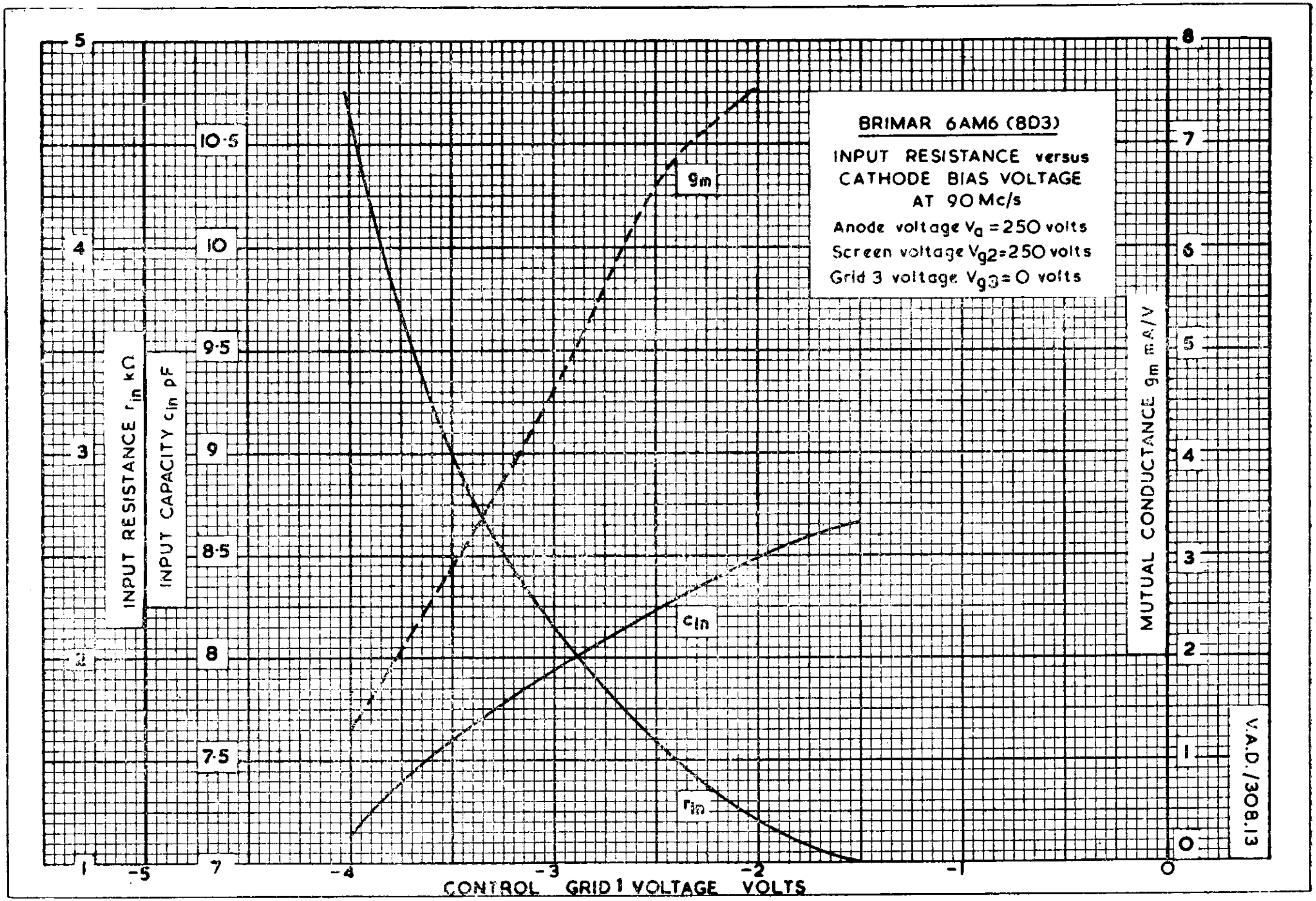

BRIMAR 6AM6 (8D3)
INPUT RESISTANCE versus SCREEN VOLTAGE AT 50 Mc/s
Anode voltage Va = 250 volts
Grid 3 voltage Vg3 = 0 volts
Cathode bias resistor Rk = 160Ω
INPUT RESISTANCE rin kΩ
INPUT CAPACITY cin pF
MUTUAL CONDUCTANCE gm mA/V
SCREEN VOLTAGE VOLTS
gm
cin
rin
V.A.D./308.9


BRIMAR 6AM6/8D3
INPUT RESISTANCE versus GRID 3 VOLTAGE at 50Mc/s
Anode supply voltage $V_{a(b)}$ = 250 volts
Screen supply voltage $V_{g2(b)}$ = 250 volts
Grid 1 voltage V_{g1} = 3% of grid 3 voltage V_{g3}
Cathode bias resistor R_k = 160 ohms
INPUT RESISTANCE r_{in} kΩ
INPUT CAPACITY c_{in} pF
MUTUAL CONDUCTANCE g_m mA/V
GRID 3 VOLTAGE VOLTS
g_m
r_{in}
c_{in}
-50
-40
-30
-20
-10
0
2
4
6
8
9
9.5
10
10.5
0
1
2
3
4
5
6
7
8
160Ω
3kΩ
97kΩ
50kΩ
ALL CONDENSERS ·01µF
V.A.D./308.10

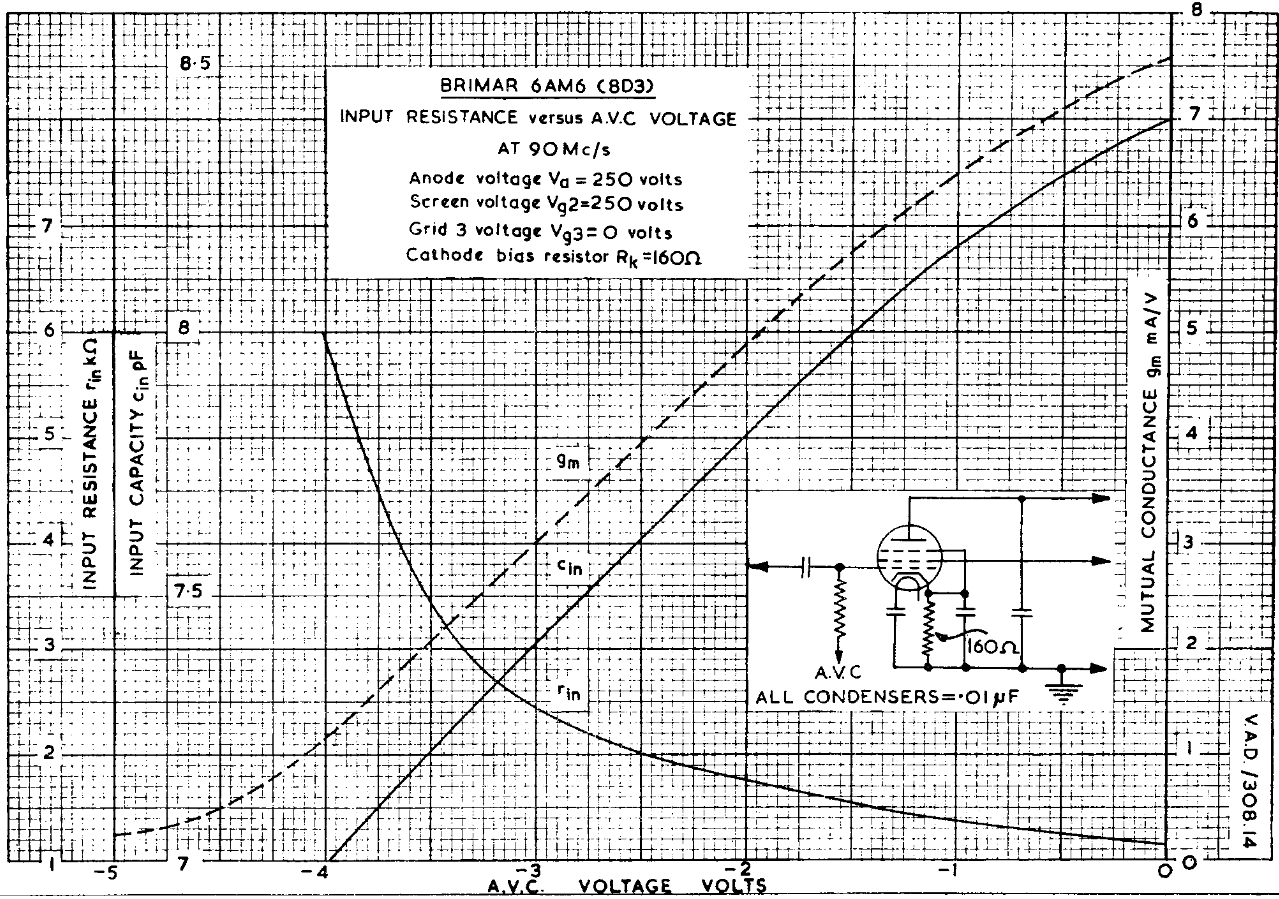


BRIMAR 6AM6/8D3
INPUT RESISTANCE versus GRID 3 VOLTAGE at 50Mc/s
Anode supply voltage $V_{a(b)}$ = 250 volts
Screen supply voltage $V_{g2(b)}$ = 250 volts
Grid 1 voltage V_{g1} = 4% of grid 3 voltage V_{g3}
Cathode bias resistor R_k = 160 ohms
ALL CONDENSERS = ·01 μF
160Ω
4kΩ
96kΩ
50kΩ
INPUT RESISTANCE r_{in} kΩ
INPUT CAPACITY c_{in} pF
MUTUAL CONDUCTANCE g_m mA/V
GRID 3 VOLTAGE VOLTS
g_m
r_{in}
c_{in}
V.A.D./308.11

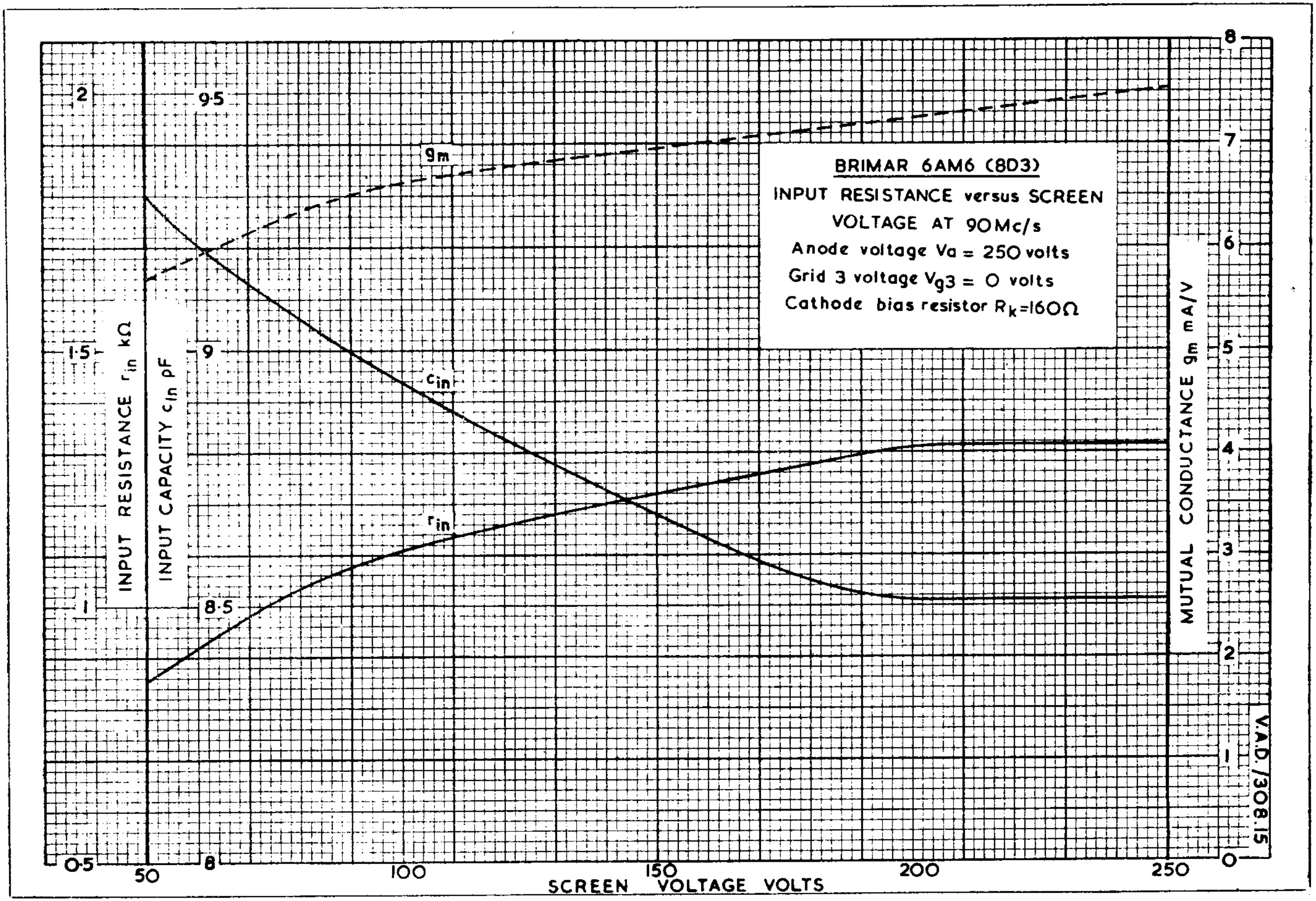

BRIMAR 6AM6/8D3
INPUT RESISTANCE versus GRID 3 VOLTAGE at 50 Mc/s
Anode supply voltage $V_{a(b)}$ = 250 volts
Screen supply voltage $V_{g2(b)}$ = 250 volts
Grid 1 voltage V_{g1} = 6% of grid 3 voltage V_{g3}
Cathode bias resistor R_k = 160 ohms
MUTUAL CONDUCTANCE g_m mA/V
INPUT CAPACITY c_{in} pF
g_m
c_{in}
r_{in}
160 Ω
6k Ω
94k Ω
50k Ω
ALL CONDENSERS = ·01 µF
GRID 3 VOLTAGE VOLTS
V.A.D./308 12



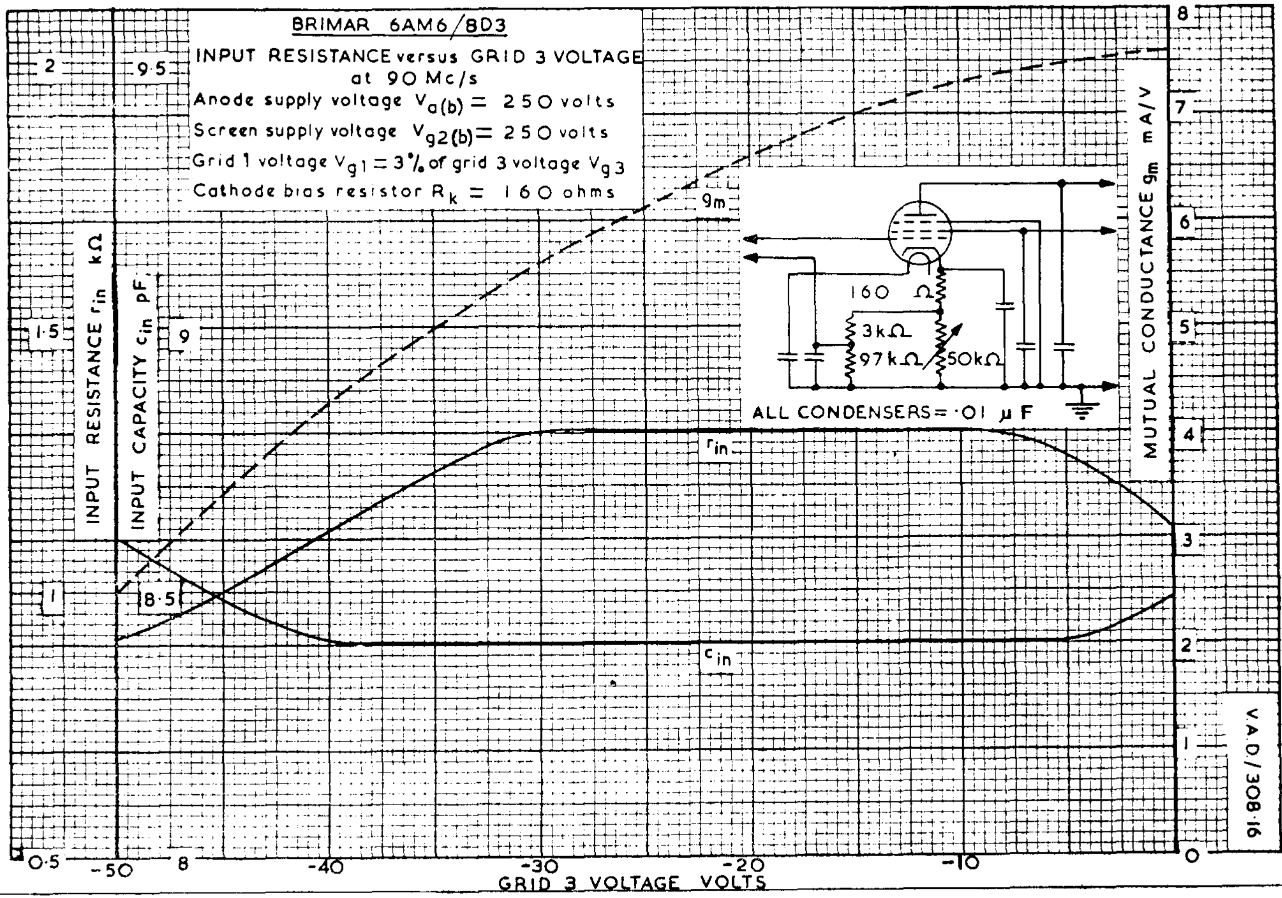
BRIMAR 6AM6 (8D3)
INPUT RESISTANCE versus
CATHODE BIAS VOLTAGE
AT 90 Mc/s
Anode voltage Va = 250 volts
Screen voltage Vg2 = 250 volts
Grid 3 voltage Vg3 = 0 volts
INPUT RESISTANCE rin kΩ
INPUT CAPACITY cin pF
MUTUAL CONDUCTANCE gm mA/V
CONTROL GRID 1 VOLTAGE VOLTS
gm
cin
rin
V.A.D. /308.13



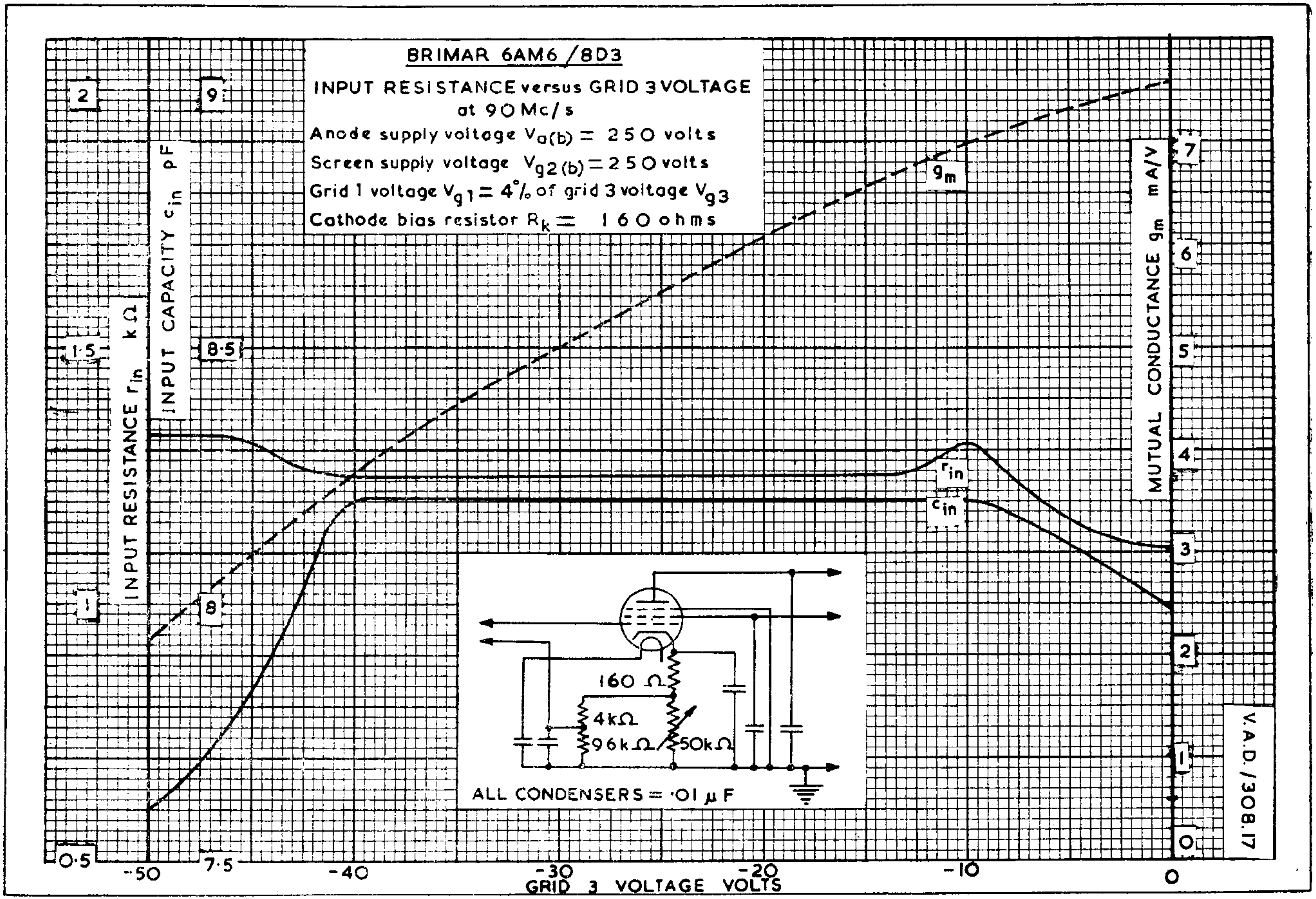
BRIMAR 6AM6 (8D3)
INPUT RESISTANCE versus A.V.C VOLTAGE
AT 90 Mc/s
Anode voltage Va = 250 volts
Screen voltage Vg2=250 volts
Grid 3 voltage Vg3= O volts
Cathode bias resistor Rk =160Ω
INPUT RESISTANCE rin kΩ
INPUT CAPACITY cin pF
MUTUAL CONDUCTANCE gm mA/V
gm
cin
rin
160Ω
A.V.C
ALL CONDENSERS=·01μF
A.V.C. VOLTAGE VOLTS
V.A.D. /308.14



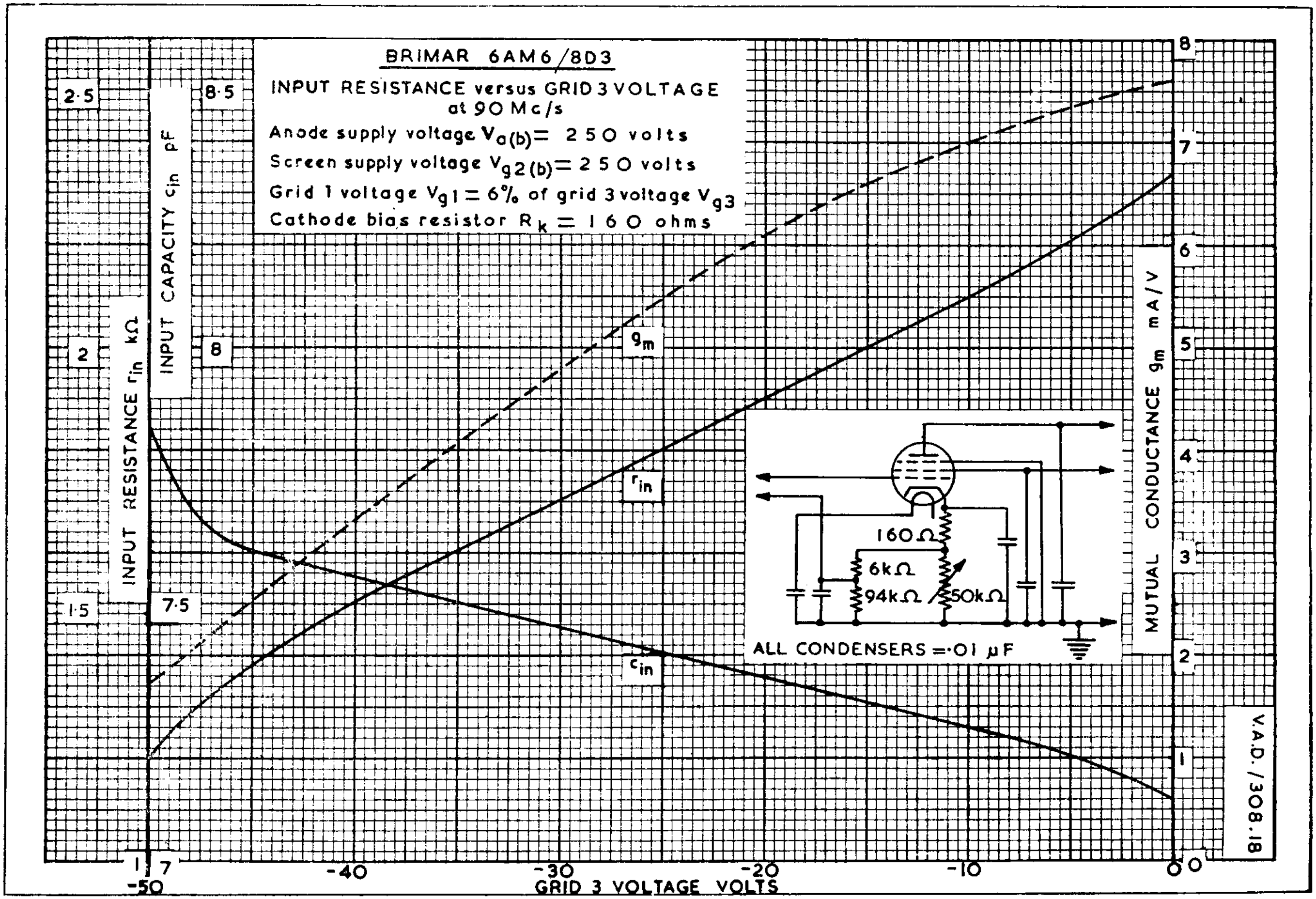
BRIMAR 6AM6 (8D3)
INPUT RESISTANCE versus SCREEN VOLTAGE AT 90Mc/s
Anode voltage Va = 250 volts
Grid 3 voltage Vg3 = 0 volts
Cathode bias resistor Rk=160Ω
INPUT RESISTANCE rin kΩ
INPUT CAPACITY cin pF
MUTUAL CONDUCTANCE gm mA/V
SCREEN VOLTAGE VOLTS
gm
cin
rin
V.A.D./308.15



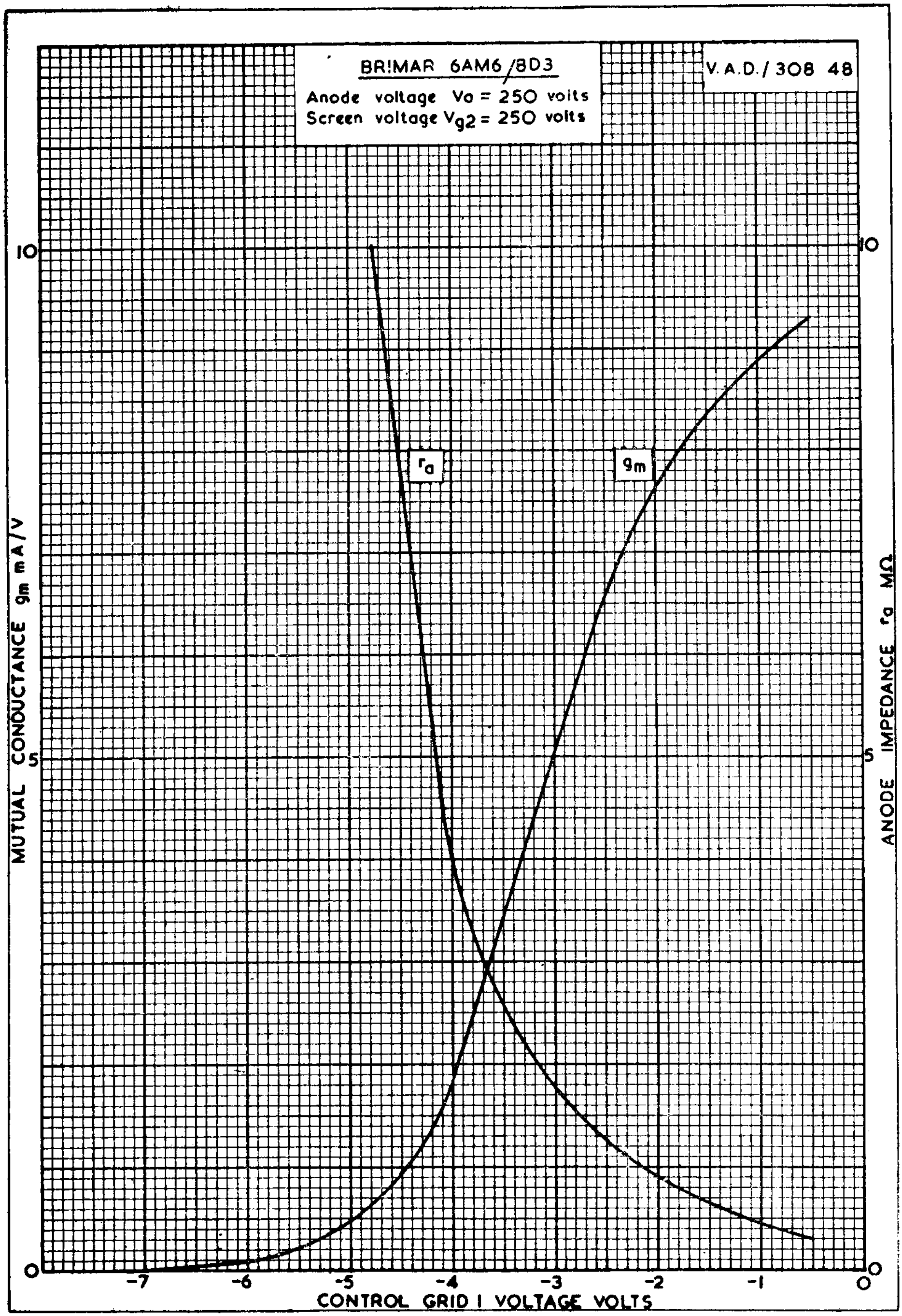
BRIMAR 6AM6/8D3
INPUT RESISTANCE versus GRID 3 VOLTAGE at 90 Mc/s
Anode supply voltage $V_{a(b)}$ = 250 volts
Screen supply voltage $V_{g2(b)}$ = 250 volts
Grid 1 voltage V_{g1} = 3% of grid 3 voltage V_{g3}
Cathode bias resistor R_k = 160 ohms
160 Ω
3 kΩ
97 kΩ
50 kΩ
ALL CONDENSERS = ·01 μF
g_m
r_{in}
c_{in}
INPUT RESISTANCE r_{in} kΩ
INPUT CAPACITY c_{in} pF
MUTUAL CONDUCTANCE g_m mA/V
GRID 3 VOLTAGE VOLTS
2
1·5
1
0·5
9·5
9
8·5
8
-50
-40
-30
-20
-10
0
1
2
3
4
5
6
7
8
V.A.D./308·16



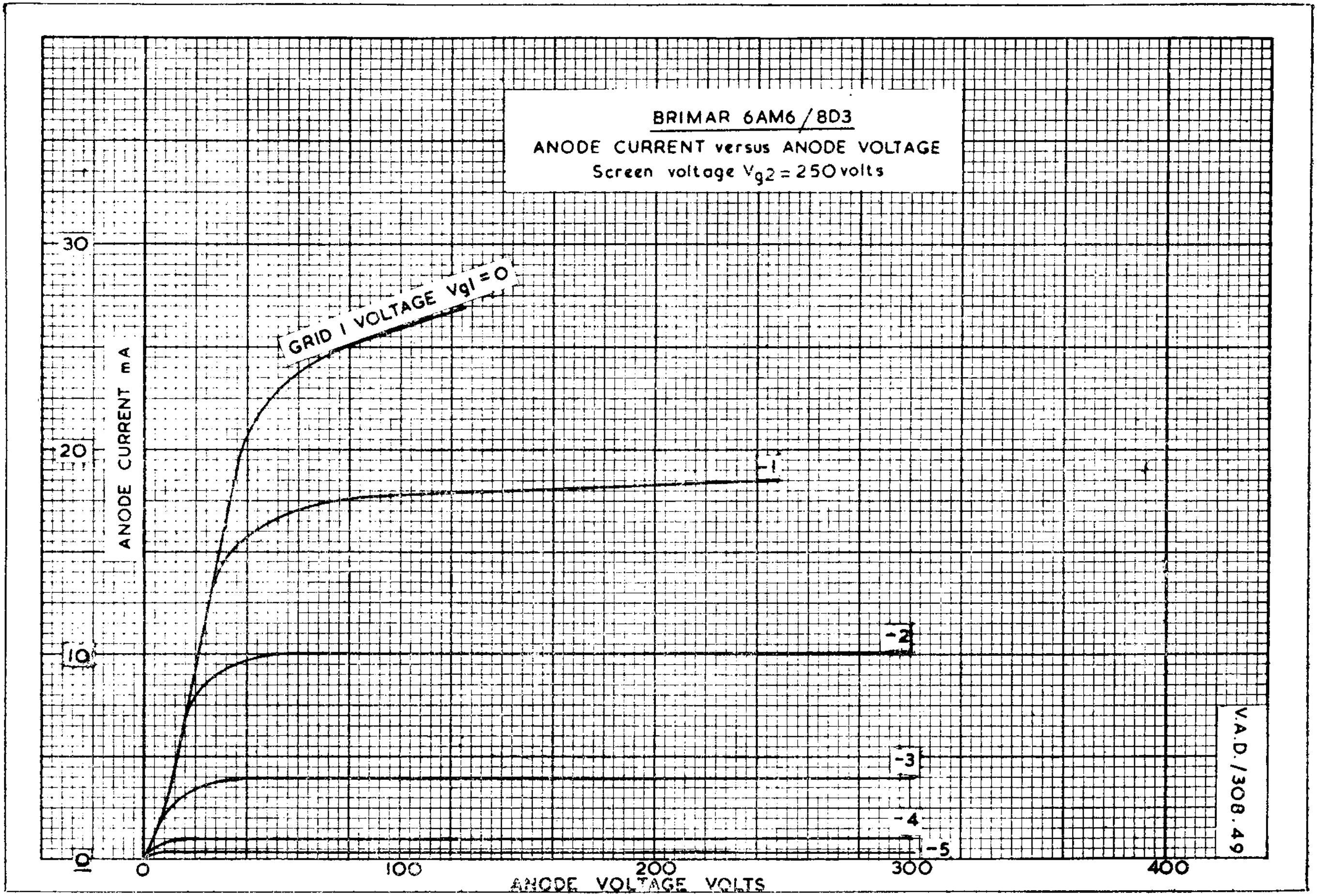
BRIMAR 6AM6 / 8D3
INPUT RESISTANCE versus GRID 3 VOLTAGE at 90 Mc/s
Anode supply voltage $V_{a(b)}$ = 250 volts
Screen supply voltage $V_{g2(b)}$ = 250 volts
Grid 1 voltage V_{g1} = 4% of grid 3 voltage V_{g3}
Cathode bias resistor R_k = 160 ohms
INPUT RESISTANCE r_{in} kΩ
INPUT CAPACITY c_{in} pF
MUTUAL CONDUCTANCE g_m mA/V
g_m
r_{in}
c_{in}
160 Ω
4kΩ
96kΩ
50kΩ
ALL CONDENSERS = ·01 μF
GRID 3 VOLTAGE VOLTS
-50
-40
-30
-20
-10
0
V.A.D. / 308.17



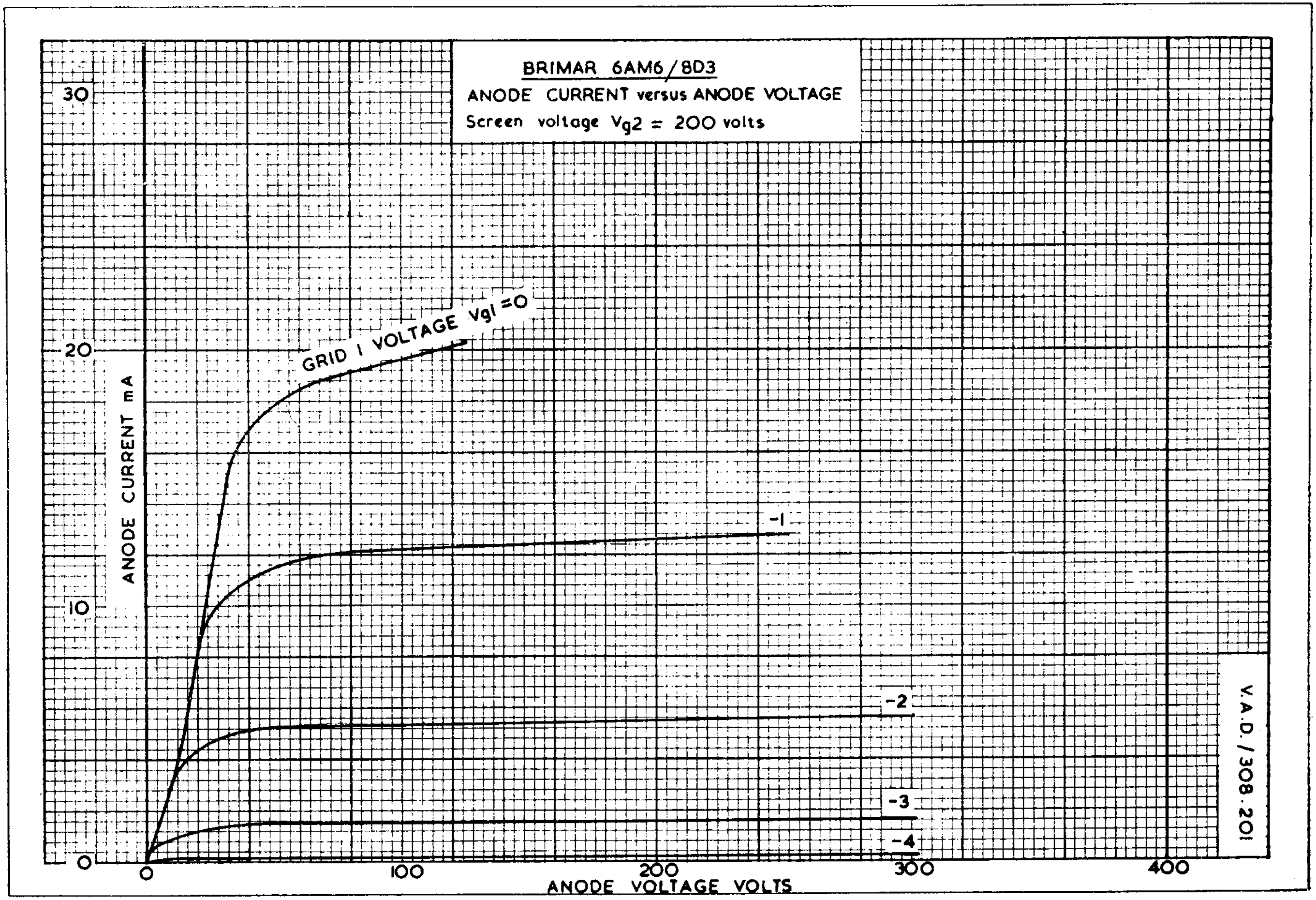
BRIMAR 6AM6/8D3
INPUT RESISTANCE versus GRID 3 VOLTAGE at 90 Mc/s
Anode supply voltage $V_{a(b)}$ = 250 volts
Screen supply voltage $V_{g2(b)}$ = 250 volts
Grid 1 voltage V_{g1} = 6% of grid 3 voltage V_{g3}
Cathode bias resistor R_k = 160 ohms
INPUT RESISTANCE r_{in} kΩ
INPUT CAPACITY c_{in} pF
MUTUAL CONDUCTANCE g_m mA/V
GRID 3 VOLTAGE VOLTS
g_m
r_{in}
c_{in}
160Ω
6kΩ
94kΩ
50kΩ
ALL CONDENSERS = ·01 μF
2·5
2
1·5
1
8·5
8
7·5
7
8
7
6
5
4
3
2
1
0
-50
-40
-30
-20
-10
0
V.A.D. /308.18

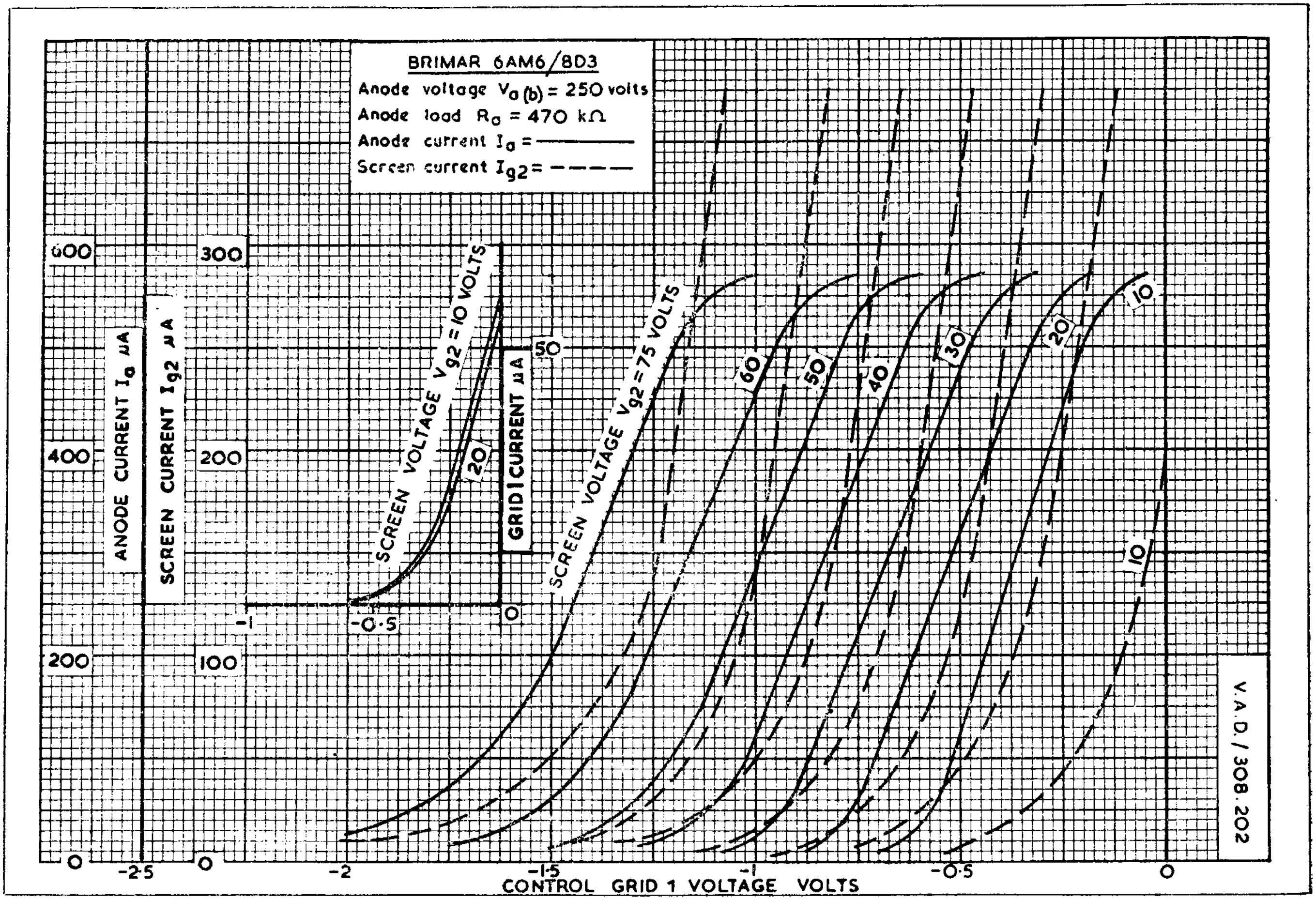


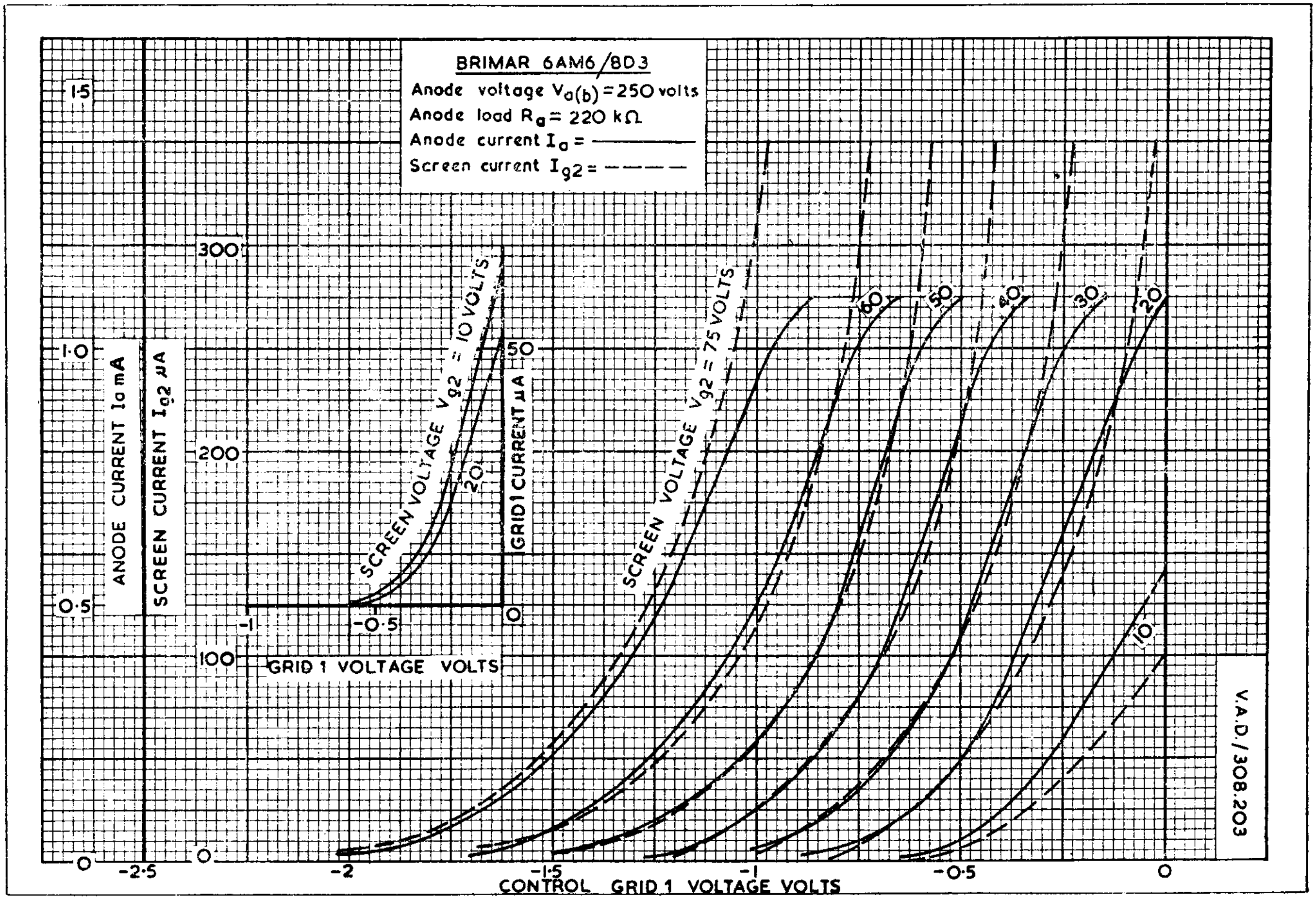
BRIMAR 6AM6/8D3
Anode voltage Va = 250 volts
Screen voltage Vg2 = 250 volts
V.A.D./308 48
ra
gm
MUTUAL CONDUCTANCE gm mA/V
ANODE IMPEDANCE ra MΩ
CONTROL GRID 1 VOLTAGE VOLTS
10
5
0
-7
-6
-5
-4
-3
-2
-1
0

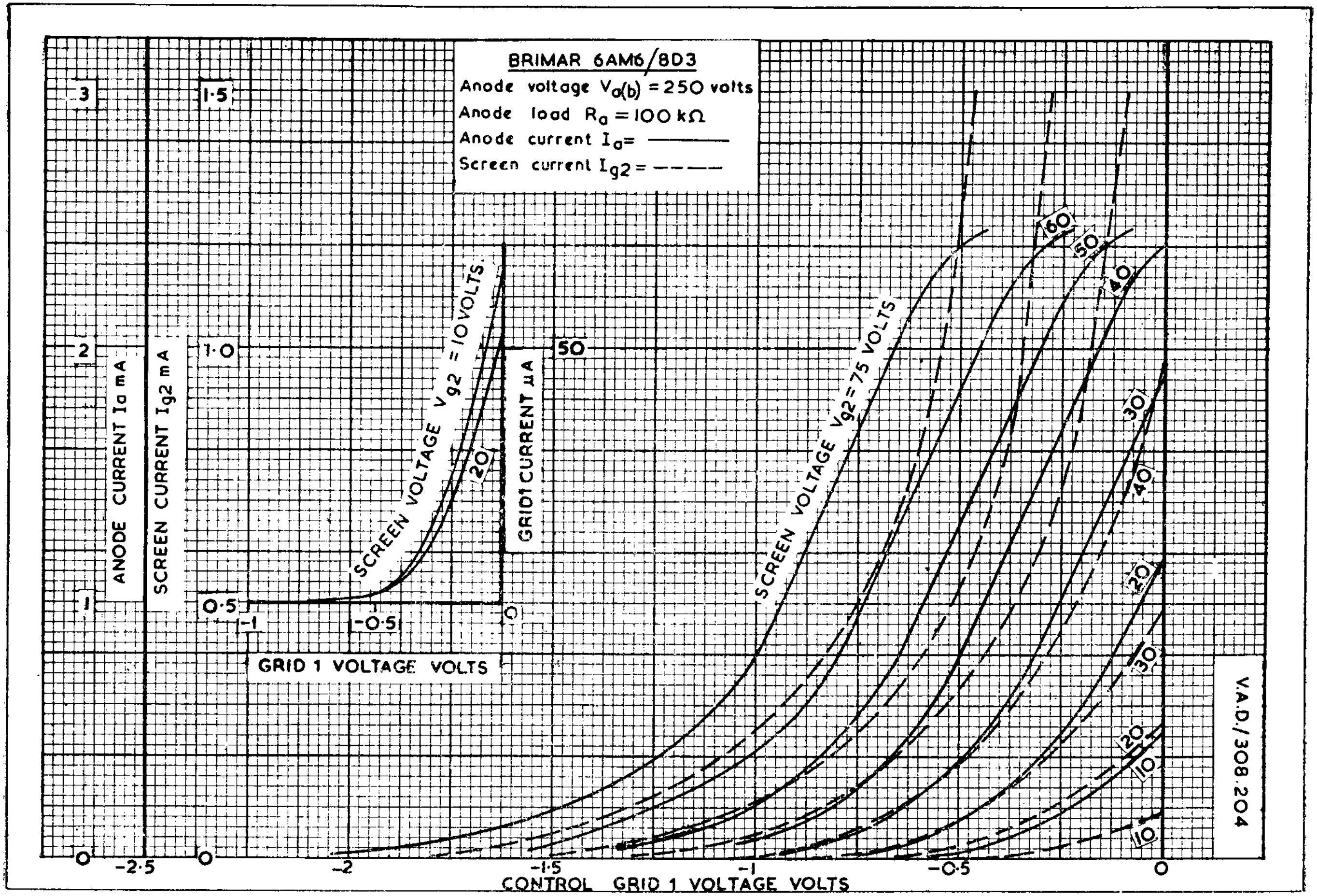


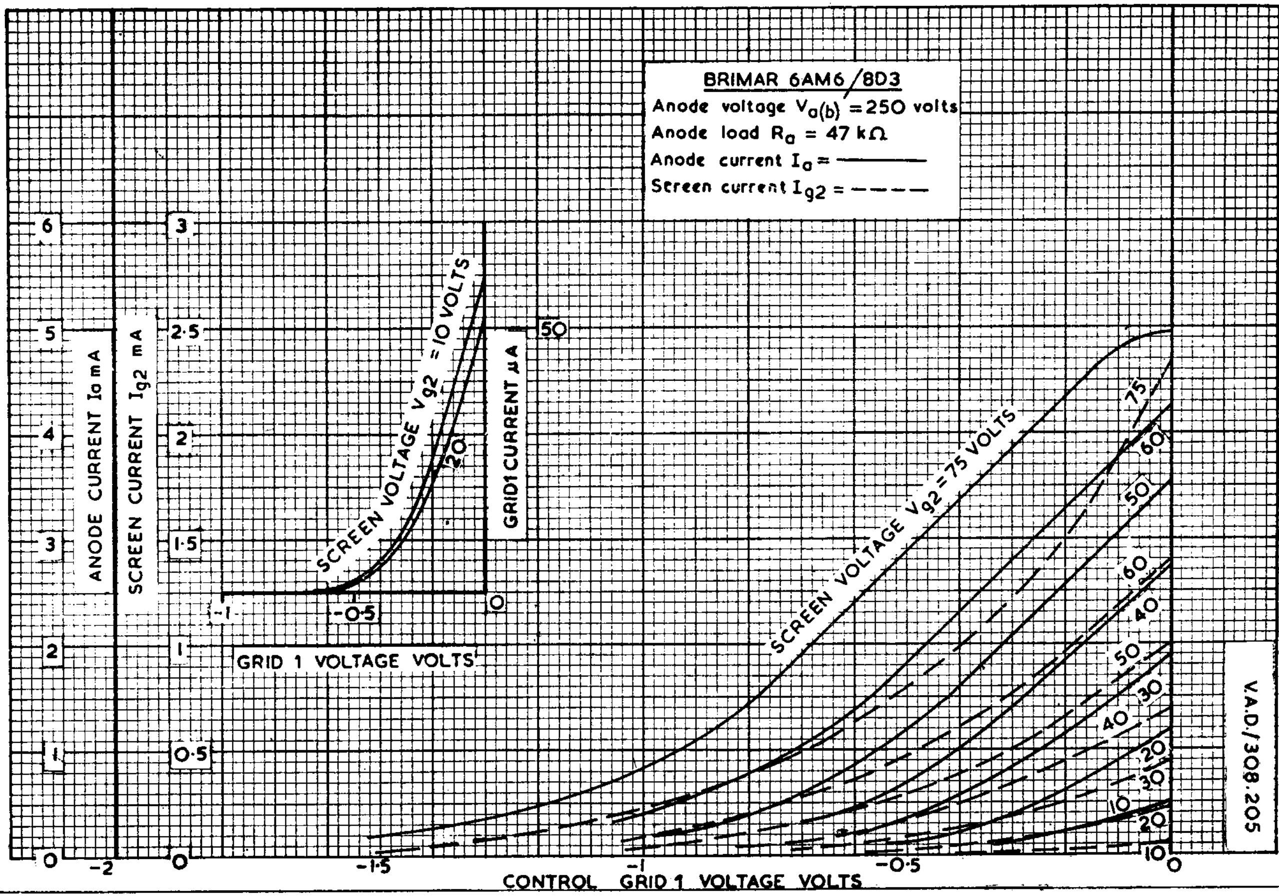
BRIMAR 6AM6 / 8D3
ANODE CURRENT versus ANODE VOLTAGE
Screen voltage V_{g2} = 250 volts
GRID 1 VOLTAGE Vg1 = 0
-1
-2
-3
-4
-5
ANODE CURRENT mA
ANODE VOLTAGE VOLTS
0
100
200
300
400
10
20
30
V.A.D./308.49

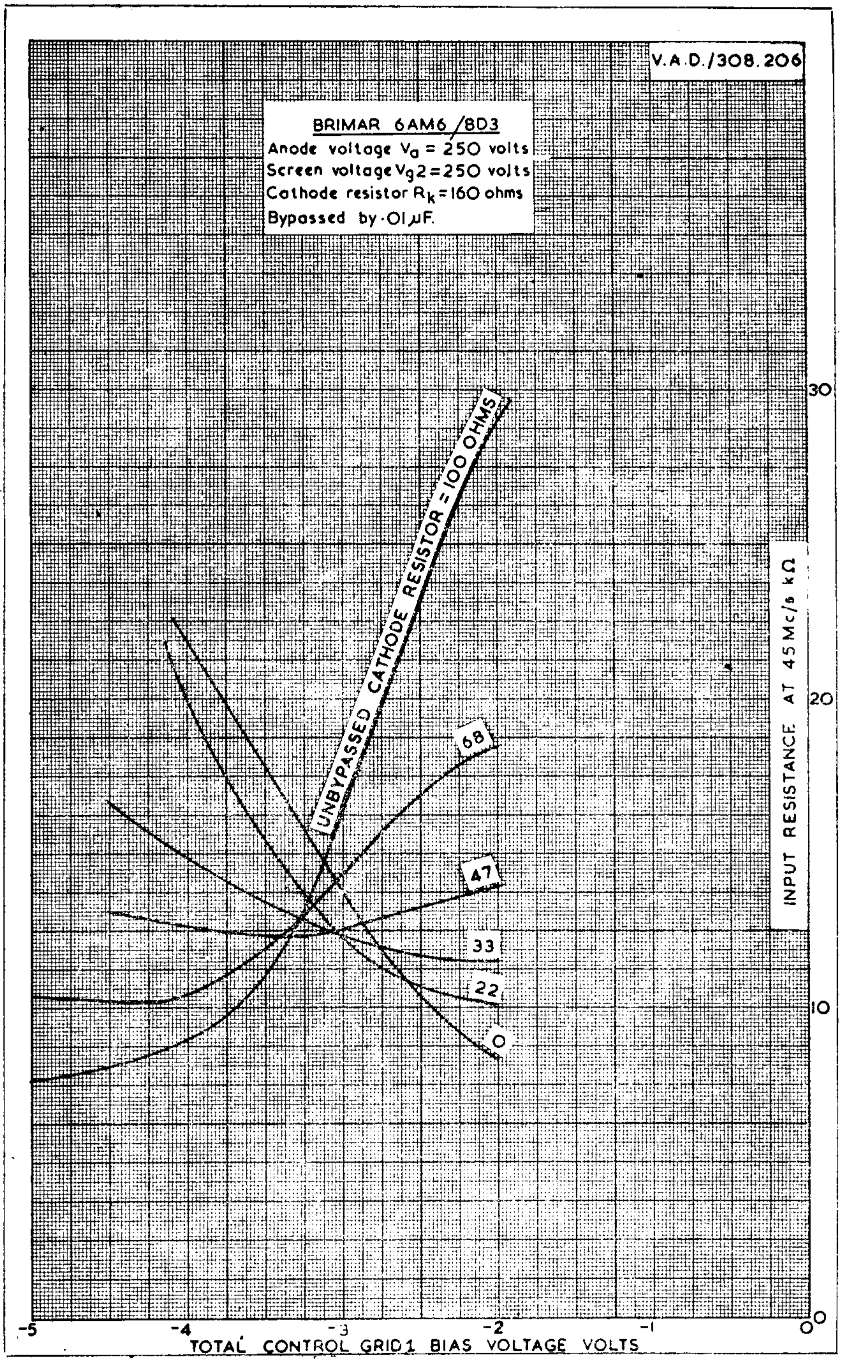

BRIMAR 6AM6/8D3
ANODE CURRENT versus ANODE VOLTAGE
Screen voltage Vg2 = 200 volts
GRID 1 VOLTAGE Vg1 = 0
-1
-2
-3
-4
ANODE CURRENT mA
30
20
10
0
0
100
200
300
400
ANODE VOLTAGE VOLTS
V.A.D./308.201

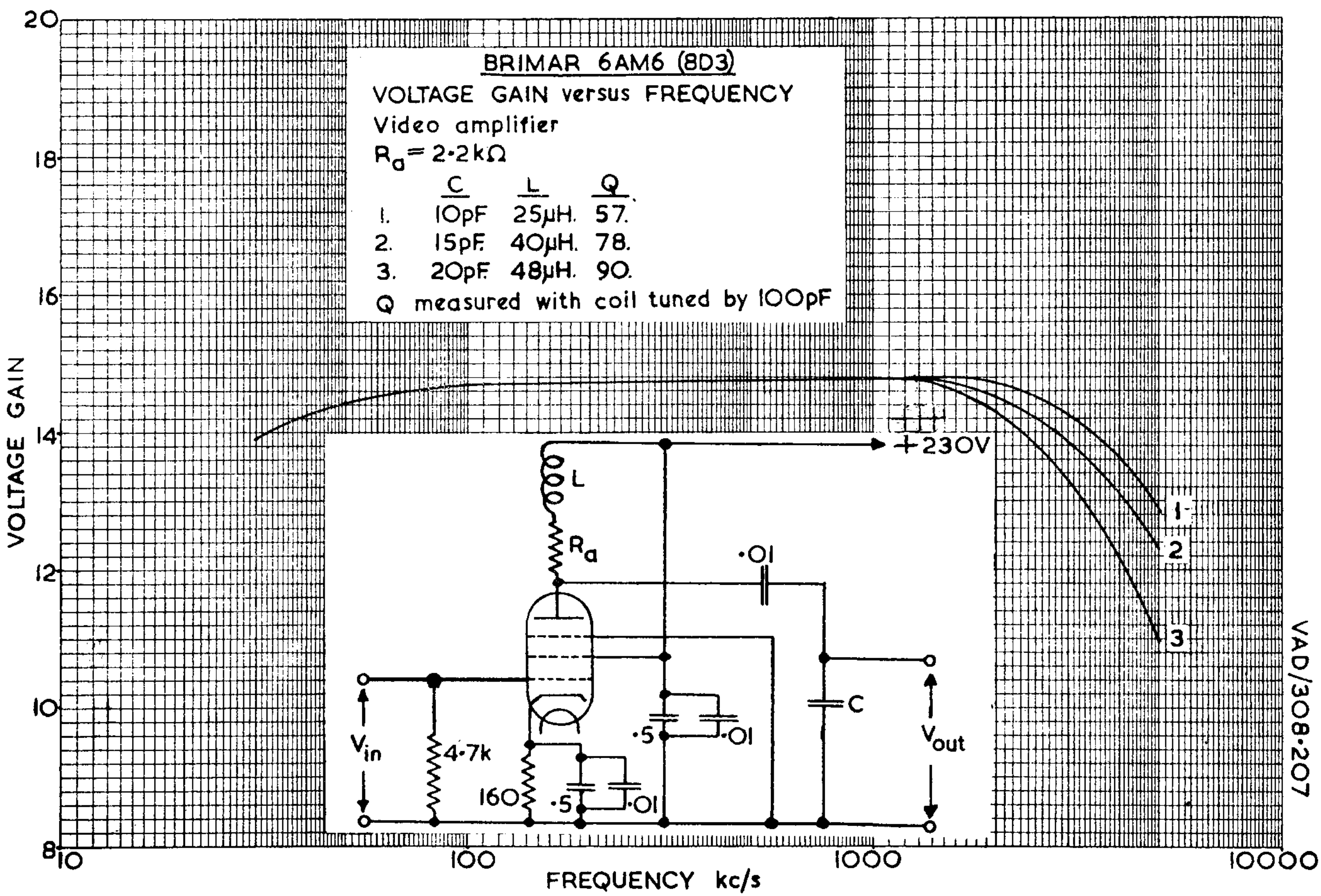

BRIMAR 6AM6/8D3
Anode voltage Va(b) = 250 volts
Anode load Ra = 470 kΩ
Anode current Ia = ———
Screen current Ig2 = – – – –
ANODE CURRENT Ia µA
SCREEN CURRENT Ig2 µA
GRID I CURRENT µA
SCREEN VOLTAGE Vg2 = 10 VOLTS
SCREEN VOLTAGE Vg2 = 75 VOLTS
CONTROL GRID 1 VOLTAGE VOLTS
600
400
200
0
300
200
100
0
-2.5
-2
-1.5
-1
-0.5
0
50
-1
-0.5
0
10
20
30
40
50
60
20
10
V.A.D./308.202

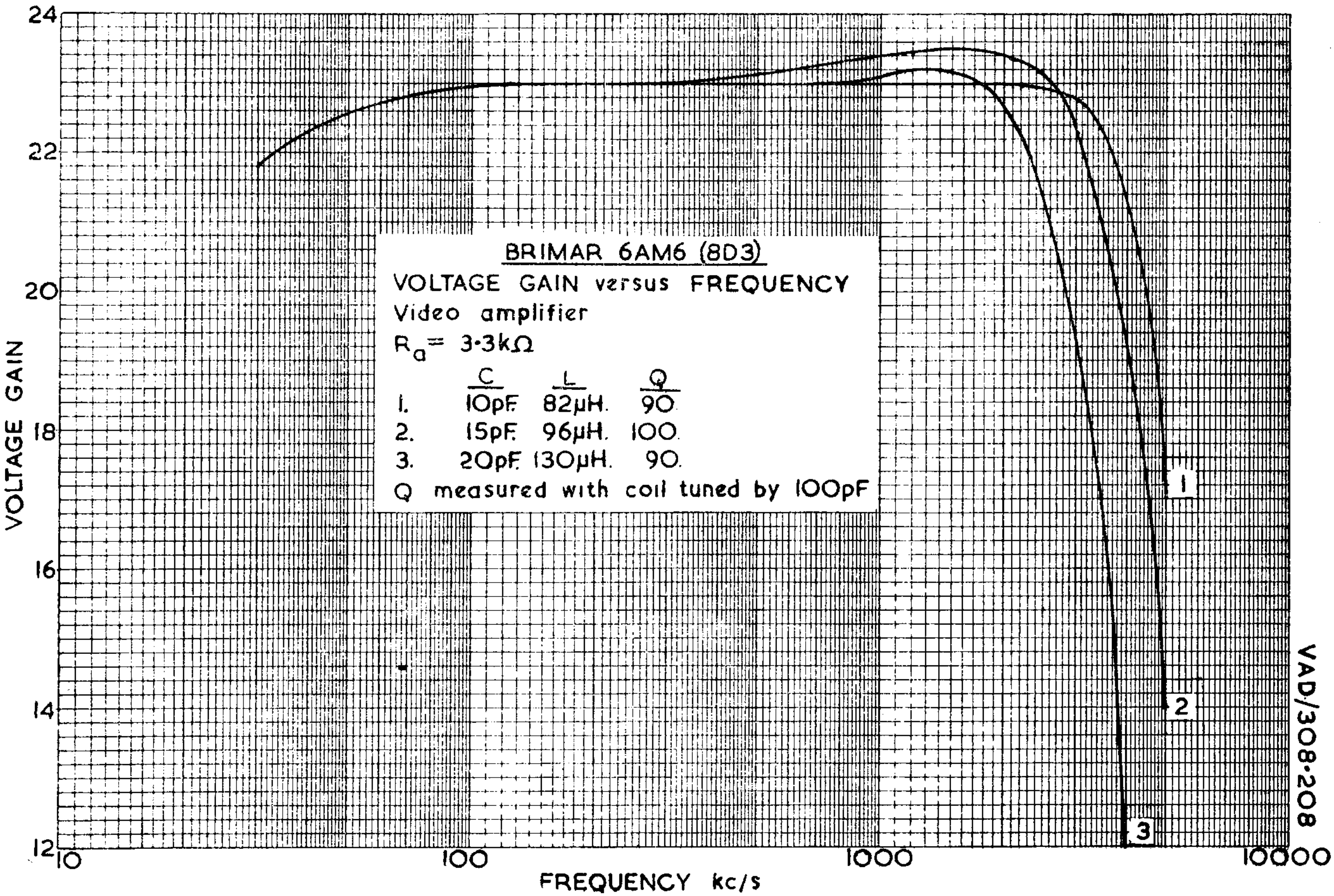

BRIMAR 6AM6/8D3
Anode voltage $V_{a(b)}$ = 250 volts
Anode load R_a = 220 kΩ
Anode current I_a = ———
Screen current I_{g2} = - - - -
SCREEN VOLTAGE V_{g2} = 10 VOLTS
20
GRID 1 CURRENT µA
GRID 1 VOLTAGE VOLTS
SCREEN VOLTAGE V_{g2} = 75 VOLTS
60
50
40
30
20
10
ANODE CURRENT Ia mA
SCREEN CURRENT I_{g2} µA
CONTROL GRID 1 VOLTAGE VOLTS
V.A.D./308.203

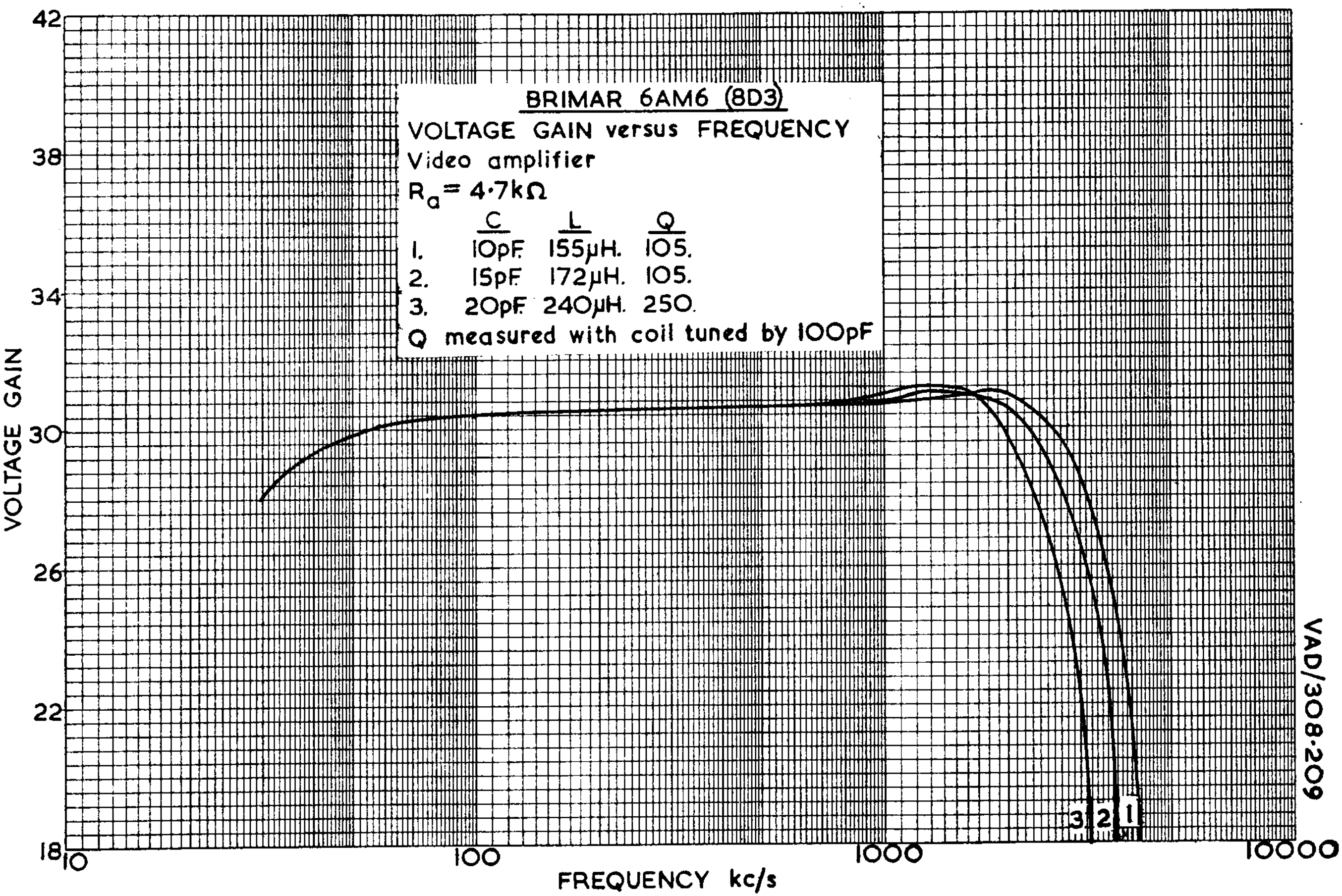

BRIMAR 6AM6/8D3
Anode voltage $V_{a(b)}$ = 250 volts
Anode load R_a = 100 kΩ
Anode current I_a = ————
Screen current I_{g2} = – – – –
ANODE CURRENT Ia mA
SCREEN CURRENT Ig2 mA
GRID1 CURRENT µA
GRID 1 VOLTAGE VOLTS
SCREEN VOLTAGE V_{g2} = 10 VOLTS
SCREEN VOLTAGE V_{g2} = 75 VOLTS
CONTROL GRID 1 VOLTAGE VOLTS
V.A.D./308.204

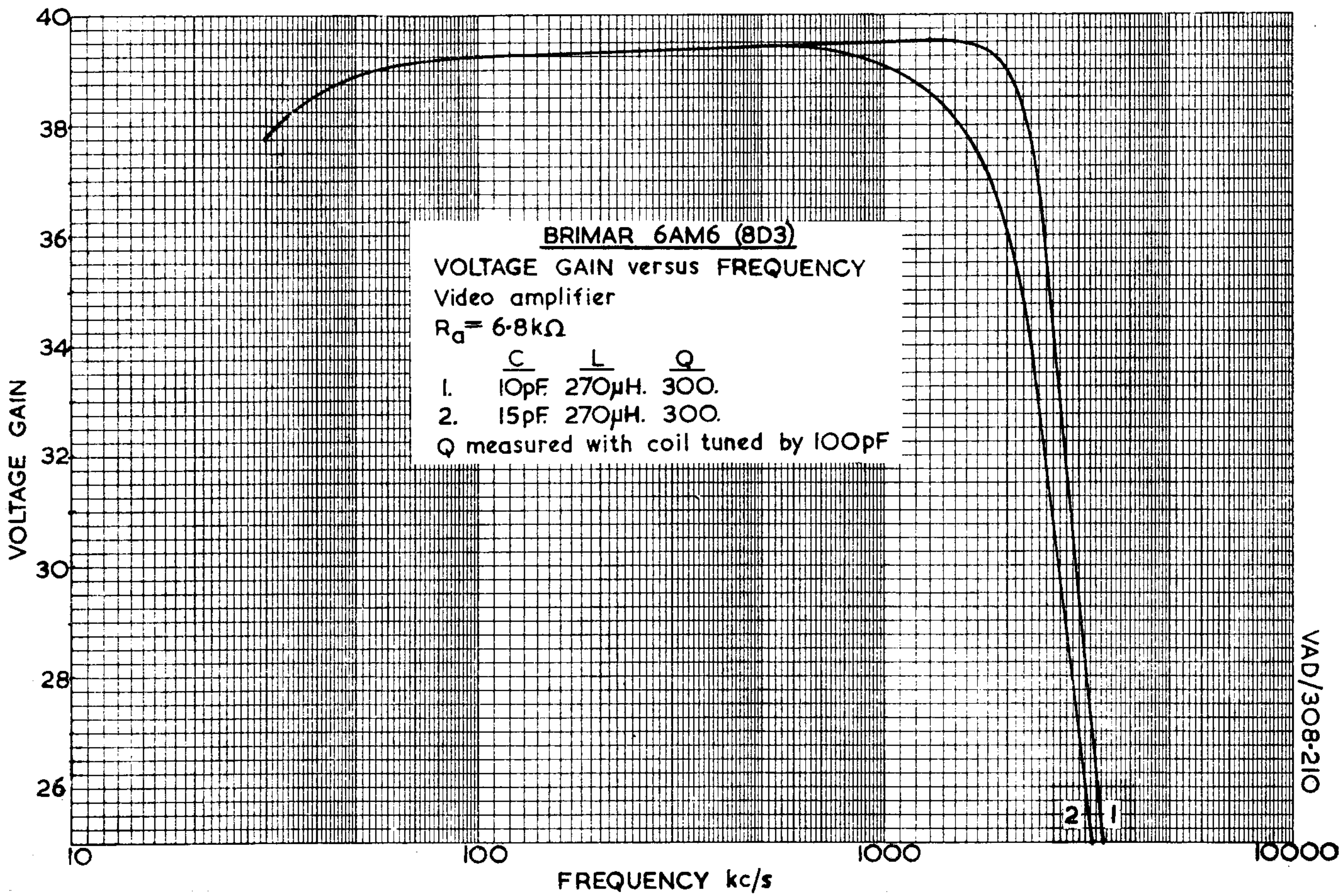

BRIMAR 6AM6/8D3
Anode voltage $V_{a(b)}$ = 250 volts
Anode load R_a = 47 kΩ
Anode current I_a = ————
Screen current I_{g2} = – – – –
ANODE CURRENT Ia mA
SCREEN CURRENT I_{g2} mA
GRID1 CURRENT µA
SCREEN VOLTAGE V_{g2} = 10 VOLTS
SCREEN VOLTAGE V_{g2} = 75 VOLTS
GRID 1 VOLTAGE VOLTS
CONTROL GRID 1 VOLTAGE VOLTS
V.A.D./308.205

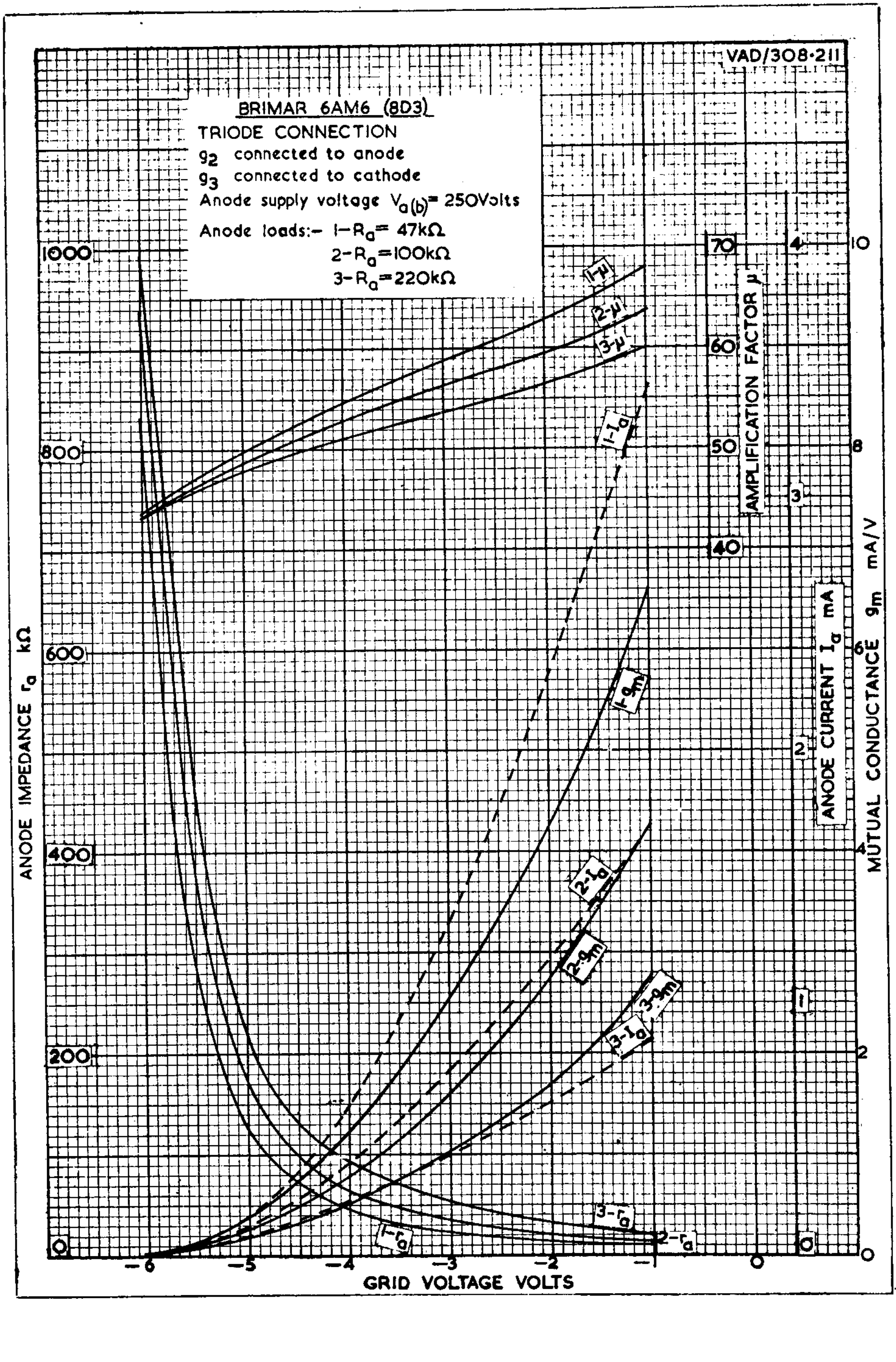

V.A.D./308.206
BRIMAR 6AM6/8D3
Anode voltage V_a = 250 volts
Screen voltage V_{g2} = 250 volts
Cathode resistor R_k = 160 ohms
Bypassed by ·01 µF.
UNBYPASSED CATHODE RESISTOR = 100 OHMS
68
47
33
22
0
30
20
10
0
-5
-4
-3
-2
-1
0
TOTAL CONTROL GRID 1 BIAS VOLTAGE VOLTS
INPUT RESISTANCE AT 45 Mc/s kΩ

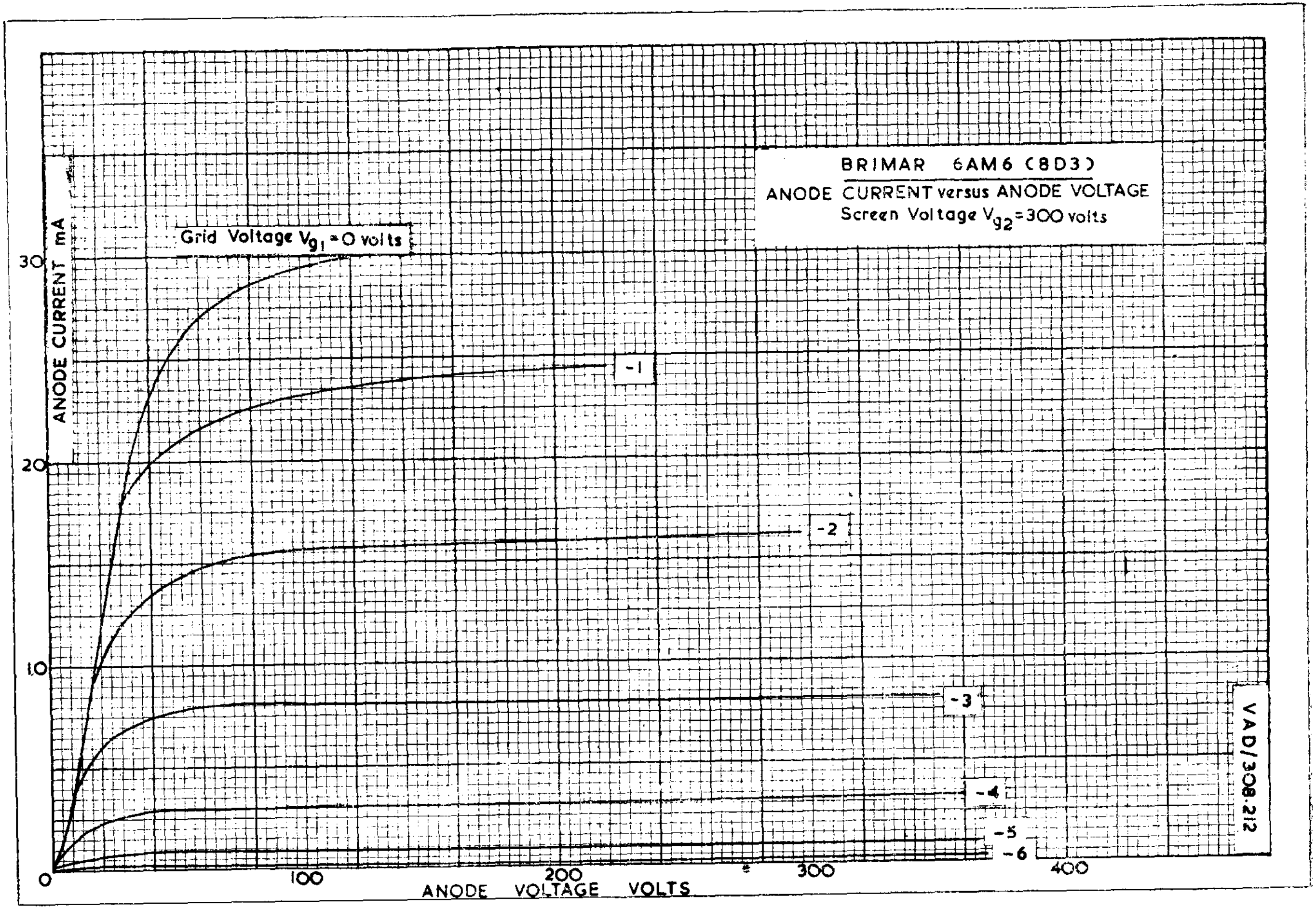

BRIMAR 6AM6 (8D3)
VOLTAGE GAIN versus FREQUENCY
Video amplifier
Ra = 2·2kΩ
C L Q
1. 10pF 25μH. 57.
2. 15pF 40μH. 78.
3. 20pF 48μH. 90.
Q measured with coil tuned by 100pF
VOLTAGE GAIN
FREQUENCY kc/s
+230V
L
Ra
·01
·5
4·7k
160
C
Vin
Vout
1
2
3
VAD/308·207


BRIMAR 6AM6 (8D3)
VOLTAGE GAIN versus FREQUENCY
Video amplifier
Ra= 3·3kΩ
C L Q
1. 10pF 82μH. 90
2. 15pF 96μH. 100
3. 20pF 130μH. 90
Q measured with coil tuned by 100pF
VOLTAGE GAIN
24
22
20
18
16
14
12
10
100
1000
10000
FREQUENCY kc/s
1
2
3
VAD/308·208

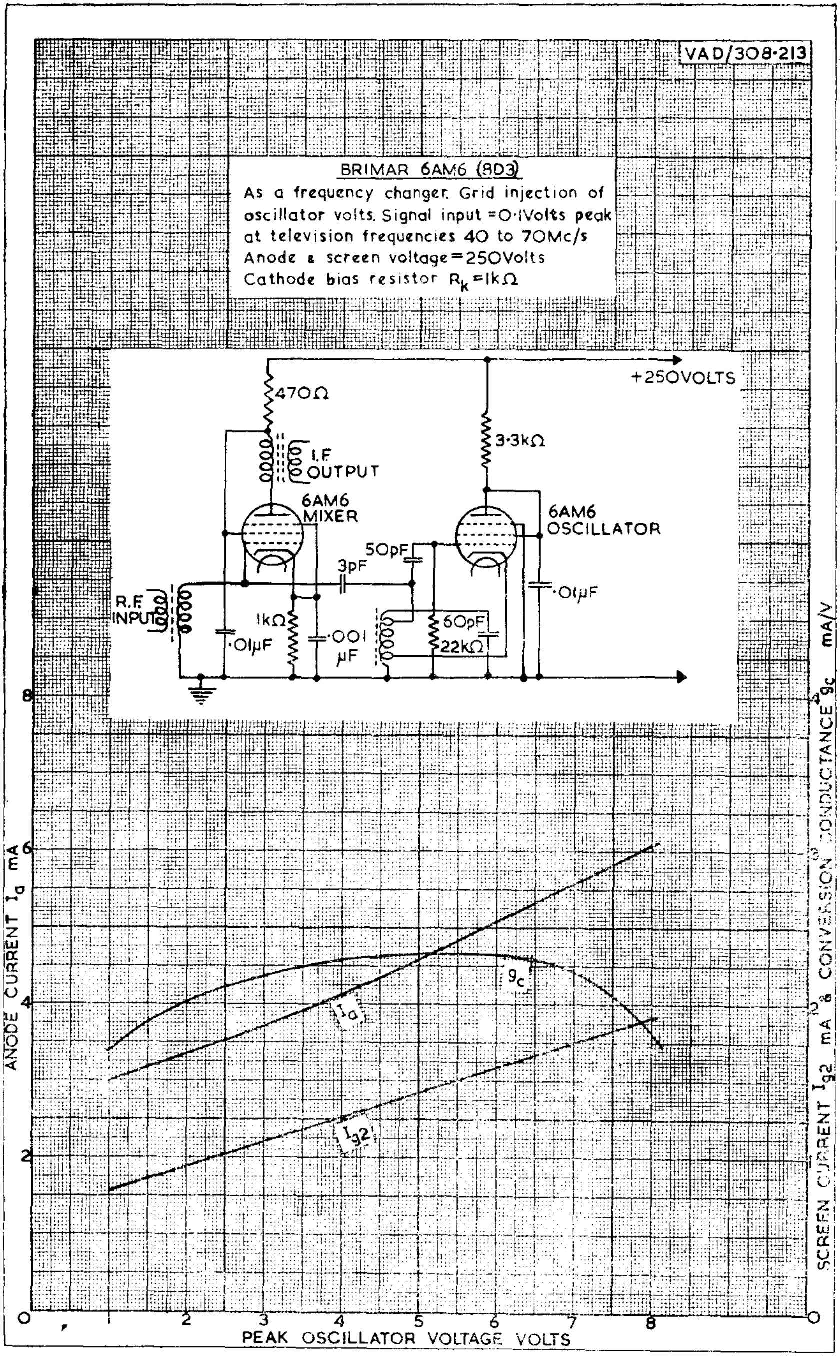

BRIMAR 6AM6 (8D3)
VOLTAGE GAIN versus FREQUENCY
Video amplifier
$R_a = 4{\cdot}7k\Omega$
C L Q
1. 10pF 155μH. 105.
2. 15pF 172μH. 105.
3. 20pF 240μH. 250.
Q measured with coil tuned by 100pF
VOLTAGE GAIN
42
38
34
30
26
22
18
10
100
1000
10000
FREQUENCY kc/s
3
2
1
VAD/308·209

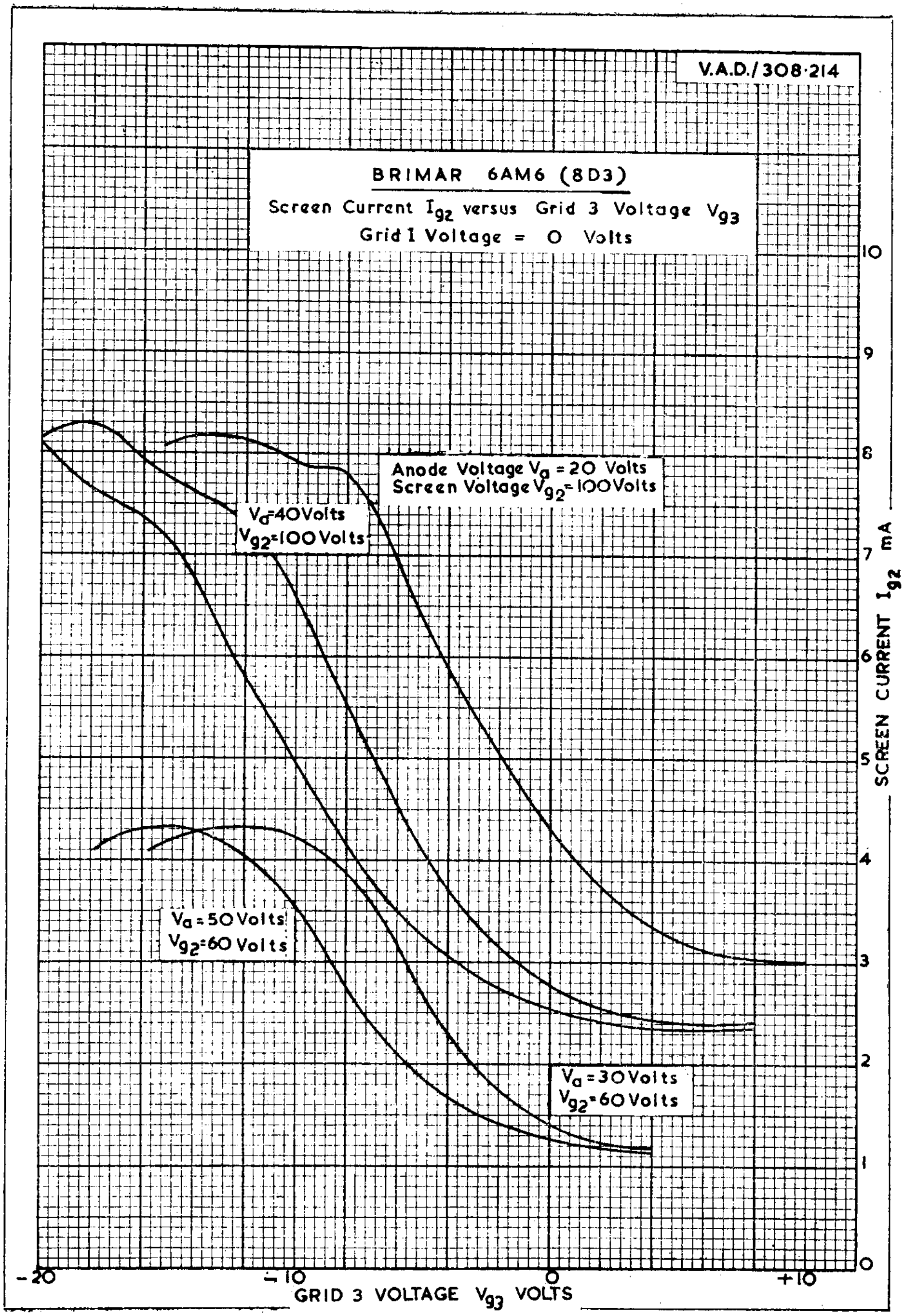

BRIMAR 6AM6 (8D3)
VOLTAGE GAIN versus FREQUENCY
Video amplifier
$R_a = 6{\cdot}8k\Omega$
C L Q
1. 10pF. 270μH. 300.
2. 15pF. 270μH. 300.
Q measured with coil tuned by 100pF
VOLTAGE GAIN
40
38
36
34
32
30
28
26
FREQUENCY kc/s
10
100
1000
10000
1
2
VAD/308-210


VAD/308·211
BRIMAR 6AM6 (8D3)
TRIODE CONNECTION
g2 connected to anode
g3 connected to cathode
Anode supply voltage Va(b)= 250Volts
Anode loads:- 1-Ra= 47kΩ
2-Ra=100kΩ
3-Ra=220kΩ
1-μ
2-μ
3-μ
1-Ia
1-gm
2-Ia
2-gm
3-gm
3-Ia
3-ra
1-ra
2-ra
ANODE IMPEDANCE ra kΩ
AMPLIFICATION FACTOR μ
ANODE CURRENT Ia mA
MUTUAL CONDUCTANCE gm mA/V
GRID VOLTAGE VOLTS
1000
800
600
400
200
0
70
60
50
40
10
8
6
4
2
0
4
3
2
1
0
−6
−5
−4
−3
−2
−1
0



BRIMAR 6AM6 (8D3)
ANODE CURRENT versus ANODE VOLTAGE
Screen Voltage Vg2=300 volts
Grid Voltage Vg1 = 0 volts
-1
-2
-3
-4
-5
-6
ANODE CURRENT mA
30
20
10
0
100
200
300
400
ANODE VOLTAGE VOLTS
VAD/308.212


VAD/308·213
BRIMAR 6AM6 (8D3)
As a frequency changer. Grid injection of oscillator volts. Signal input = 0·1Volts peak at television frequencies 40 to 70Mc/s
Anode & screen voltage = 250Volts
Cathode bias resistor R_k = 1kΩ
+250VOLTS
470Ω
3·3kΩ
I.F OUTPUT
6AM6 MIXER
6AM6 OSCILLATOR
50pF
3pF
R.F INPUT
1kΩ
·01μF
·001 μF
60pF
22kΩ
·01μF
ANODE CURRENT I_a mA
SCREEN CURRENT I_{g2} mA & CONVERSION CONDUCTANCE g_c mA/V
PEAK OSCILLATOR VOLTAGE VOLTS
g_c
I_a
I_{g2}
0
2
4
6
8
1
2
3
4
5
6
7
8
0


V.A.D./308·214
BRIMAR 6AM6 (8D3)
Screen Current I_{g2} versus Grid 3 Voltage V_{g3}
Grid 1 Voltage = 0 Volts
Anode Voltage V_a = 20 Volts
Screen Voltage V_{g2} = 100 Volts
V_a = 40 Volts
V_{g2} = 100 Volts
V_a = 50 Volts
V_{g2} = 60 Volts
V_a = 30 Volts
V_{g2} = 60 Volts
SCREEN CURRENT I_{g2} mA
0
1
2
3
4
5
6
7
8
9
10
-20
-10
0
+10
GRID 3 VOLTAGE V_{g3} VOLTS

BRIMAR

RECEIVING VALVE

6AT6

APPLICATION REPORT VAD/511.2

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

Issued March, 1950. Reprinted January, 1952.

INTRODUCTION: The Brimar 6AT6 is an indirectly heated miniature double diode triode. The triode unit and the diode unit are separate but have a common cathode. This report contains characteristics of the valve and details of its use as second detector in superheterodyne receivers.

DESCRIPTION: The valve comprises two units mounted one above the other; the diode unit is screened from the triode unit. The triode unit is of the high μ type and the whole is mounted in a standard T5½ bulb and based with a B.V.A. standard base type B7G.

CHARACTERISTICS:	Indirectly-heated oxide-coated cathode.	
	Heater Voltage	6·3 volts
	Heater Current	0·3 amperes
	Max. DC Heater-Cathode potential	250 volts
DIMENSIONS:	Max. Overall Length	2-1/8 ins.
	Max. Diameter	3/4 in.
	Max. Seated Height (excluding tip)	1-19/32 ins.
BASE:	Type B7G	
BASE CONNECTIONS:	Pin 1 Triode Grid	
	Pin 2 Cathode and Shield	
	Pin 3 Heater	
	Pin 4 Heater	
	Pin 5 Diode Anode 2	
	Pin 6 Diode Anode 1	
	Pin 7 Triode Anode	
MAXIMUM RATINGS:	Triode Unit:	
	Max. Anode Voltage	300 volts
	Max. Anode Dissipation	1·0 watts
	Diode Unit:	
	Max. Anode Current	1·0 mA
CAPACITIES (approx.):	Measured with no external shield.	
	$c_{g,a}$	2·1 pF
	c Input	2·3 pF
	c Output	1·1 pF
	$c_{h,k}$	3·5 pF
	$c_{a'd,k}$	0·65 pF
	$c_{a''d,k}$	1·4 pF
	$c_{a'd,a''d}$	1·0 pF
	$c_{at,a'd}$; $c_{at,a''d}$	0·4 pF
	$c_{g,a'd}$; $c_{g,a''d}$	0·025 pF max.

CHARACTERISTIC CURVES: Curves are attached to this report showing:

a. Triode anode current plotted against anode voltage for various values of grid voltage (Curve No. 311·11).

b. Triode anode current plotted against grid voltage for various anode voltages (Curve No. 311·12).

c. Mutual conductance (g_m), amplification factor (μ) and anode impedance (r_a) plotted against anode current (Curve No. 311·13).

d. Diode anode current against anode voltage (Curve No. 311·14).

TYPICAL OPERATING CONDITIONS

TRIODE UNIT:

Class A Amplifier:

Heater Voltage	6·3	6·3	volts
Anode Voltage	100	250	volts
Grid Voltage	—1	—3	volts
Amplification Factor	70	70	
Anode Impedance	54,000	58,000	ohms
Mutual Conductance	1·3	1·2	mA/V
Anode Current	0·8	1·0	mA

Resistance-Capacity 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 at two different supply voltages for a distortion of approximately 4%.

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

Anode Load (R_a megohms)	0·10	0·10	0·22	0·22	0·47	0·47
Grid Leak (succeeding valve) (megohms)	0·22	0·47	0·22	0·47	0·47	1·0
Cathode Resistor (ohms)	4700	4800	7000	7800	12000	14000
Output Voltage (peak)	7·5	9·1	7·3	10	10	14
Voltage Gain	27	30	30	34	36	39

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

Anode Load (R_a megohms)	0·10	0·10	0·22	0·22	0·47	0·47
Grid Leak (succeeding valve) (megohms)	0·22	0·47	0·22	0·47	0·47	1·0
Cathode Resistor (ohms)	1800	2100	2600	3300	5200	6000
Output Voltage (peak)	40	47	38	49	45	56
Voltage Gain	36	40	40	45	46	48

A graph is attached which shows the relationship of the various valve parameters under conditions of resistance capacity coupling. This graph (311·15) 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 resistor) can be obtained, also the stage gain can be calculated and an estimate made of the distortion. The graph is not drawn beyond the limits of the commencement 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 100,000 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 voltage over the range of —1 to —3 volts, the mid point being —2 volts. At this point the anode current is 0·75 mA, hence the cathode resistor should be 2700 ohms. The peak input voltage is 1 volt and the r.m.s. input 0·7 volts. Following the grid bias voltage upward it is evident that with an anode load of 100,000 ohms, the amplification factor is 78 and the anode impedance is 62,000 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 100,000 ohms in parallel with 470,000 ohms or is 83,000 ohms. The stage gain is:

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

or in the above case:

$$\frac{78 \times 83{,}000}{83{,}000 + 62{,}000} = 45.$$

The peak input voltage above was 1 volt, hence the peak output voltage will be this figure multiplied by the stage gain or 45 volts (31 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 —1 volt is 51 and at —3 volts is 31, hence the second harmonic distortion will be approximately 10% at this input.

Zero Bias Operation: The triode unit may also be used with a high value grid resistor, the bias being provided by contact potential. A summary of useful values employing a 10 megohm grid resistor and two different supply voltages for a distortion of 5% are given below.

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

Anode Load (R_a megohms)	0·22	0·22	0·47	0·47
Grid Leak (succeeding valve) (megohms)	0·22	0·47	0·47	1·0
Output Voltage (peak)	7	10	10·5	14
Voltage Gain	31	37	39	40

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

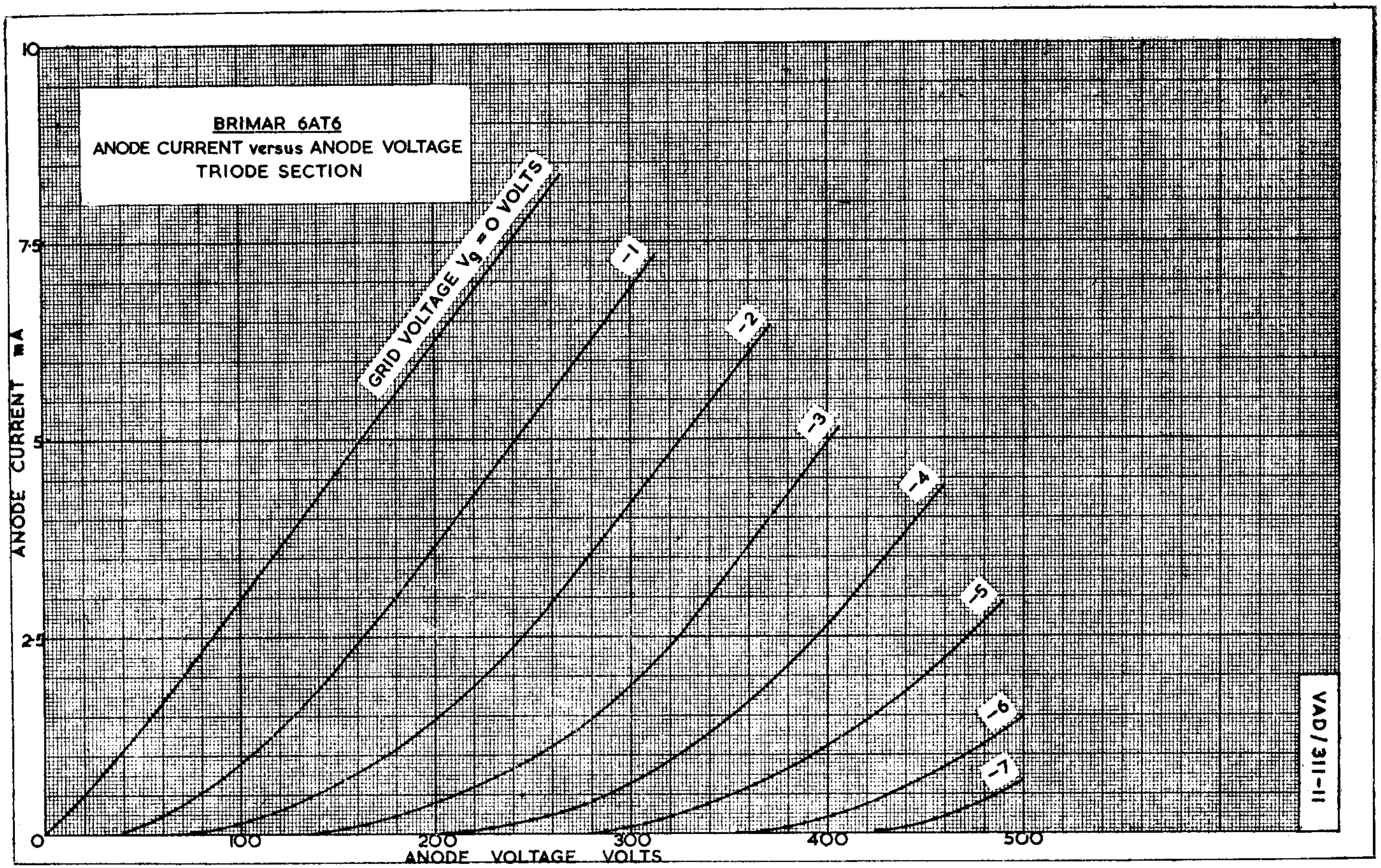
Anode Load (R_a megohms)	0·22	0·22	0·47	0·47
Grid Leak (succeeding valve) (megohms)	0·22	0·47	0·47	1·0
Output Voltage (peak)	42	54	47	60
Voltage Gain	46	51	53	56

DIODE UNIT:

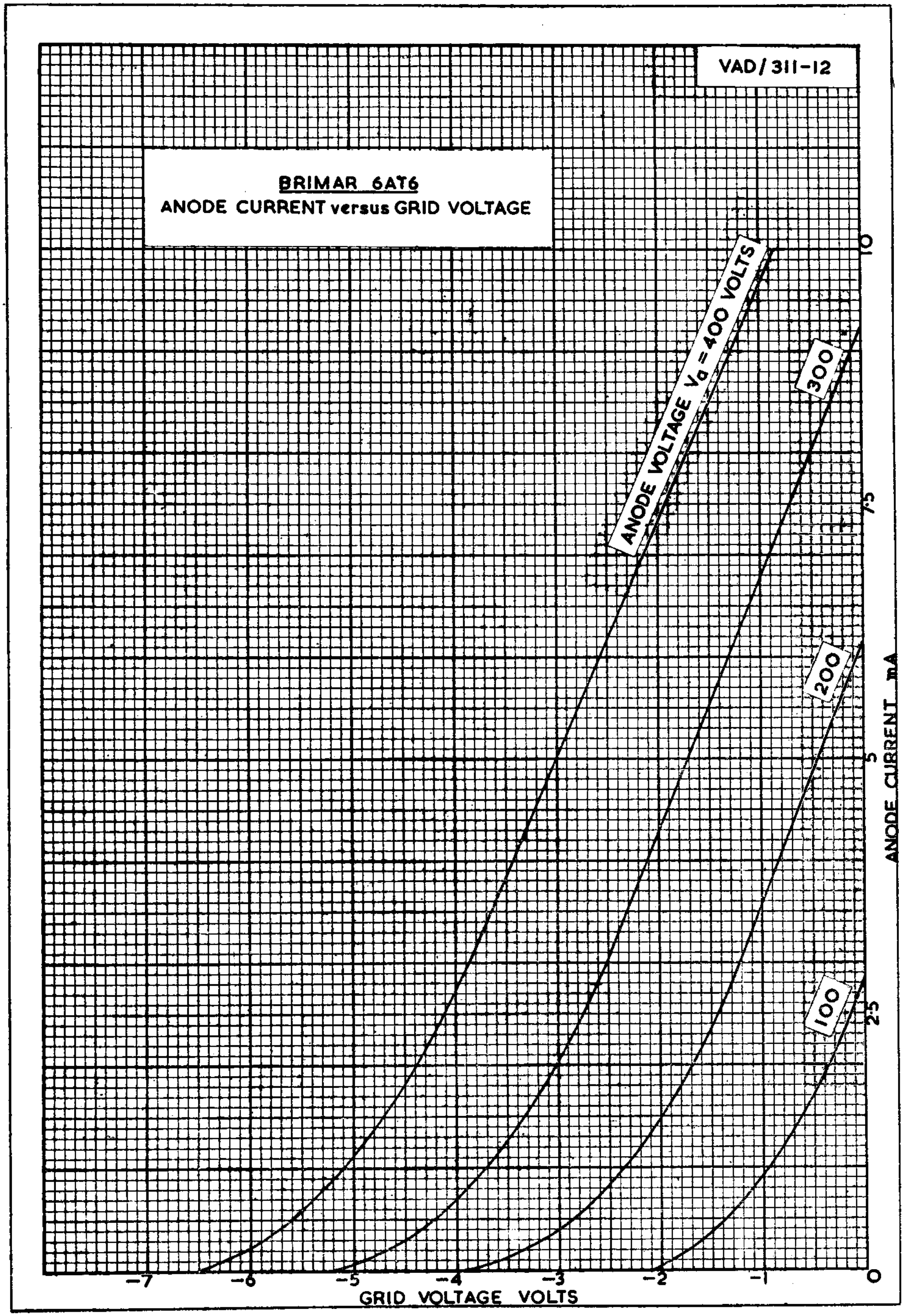
Half-Wave Rectification: A graph is attached which shows the performance of either diode when used as a signal rectifier (Curve No. 311·16). Load lines have been drawn for DC loads of 0·1, 0·22, 0·47 and 1·0 megohm. It should be remembered that in order to determine the performance, further load lines must be drawn through the operating point, having a slope equal to the load presented by the AC and DC loads in parallel.

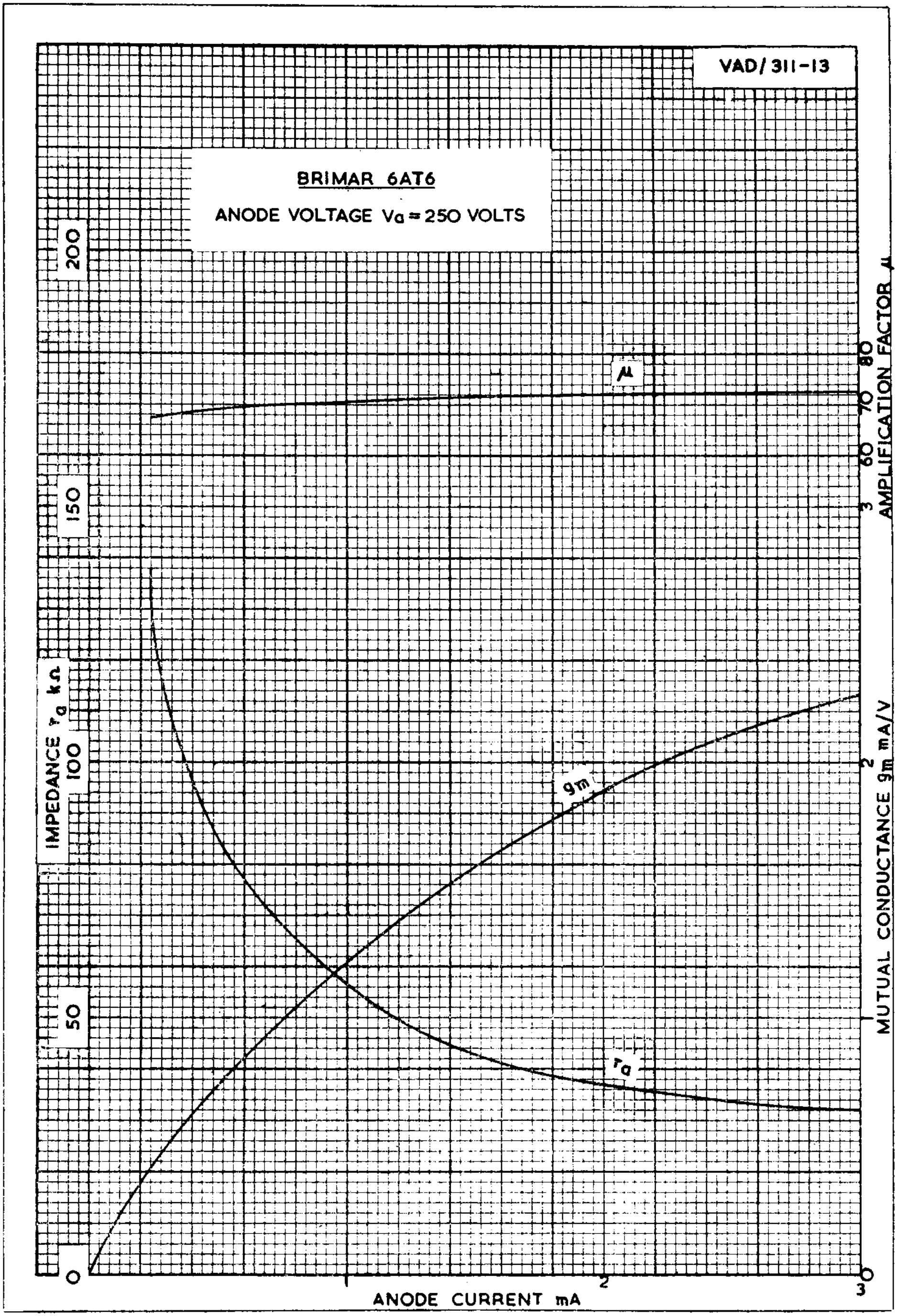
Full-Wave Rectification: The diodes may be employed as signal rectifiers in a full-wave circuit if required.

Combined Detector and AF Amplifier: The circuit (Ref. 311·55) attached shows a typical arrangement suitable for a receiver of good average performance. The IF pentode may be a type such as a Brimar 6BA6 and a following output valve may be a Brimar 6AQ5, 6BW6 or 6L6G. Using the values shown the distortion at 60% modulation will be of the order of 1·7% of second harmonic and 0·3% of third harmonic, and at 100% modulation 5% of second harmonic and 2% of third harmonic for an output of 10 volts r.m.s.

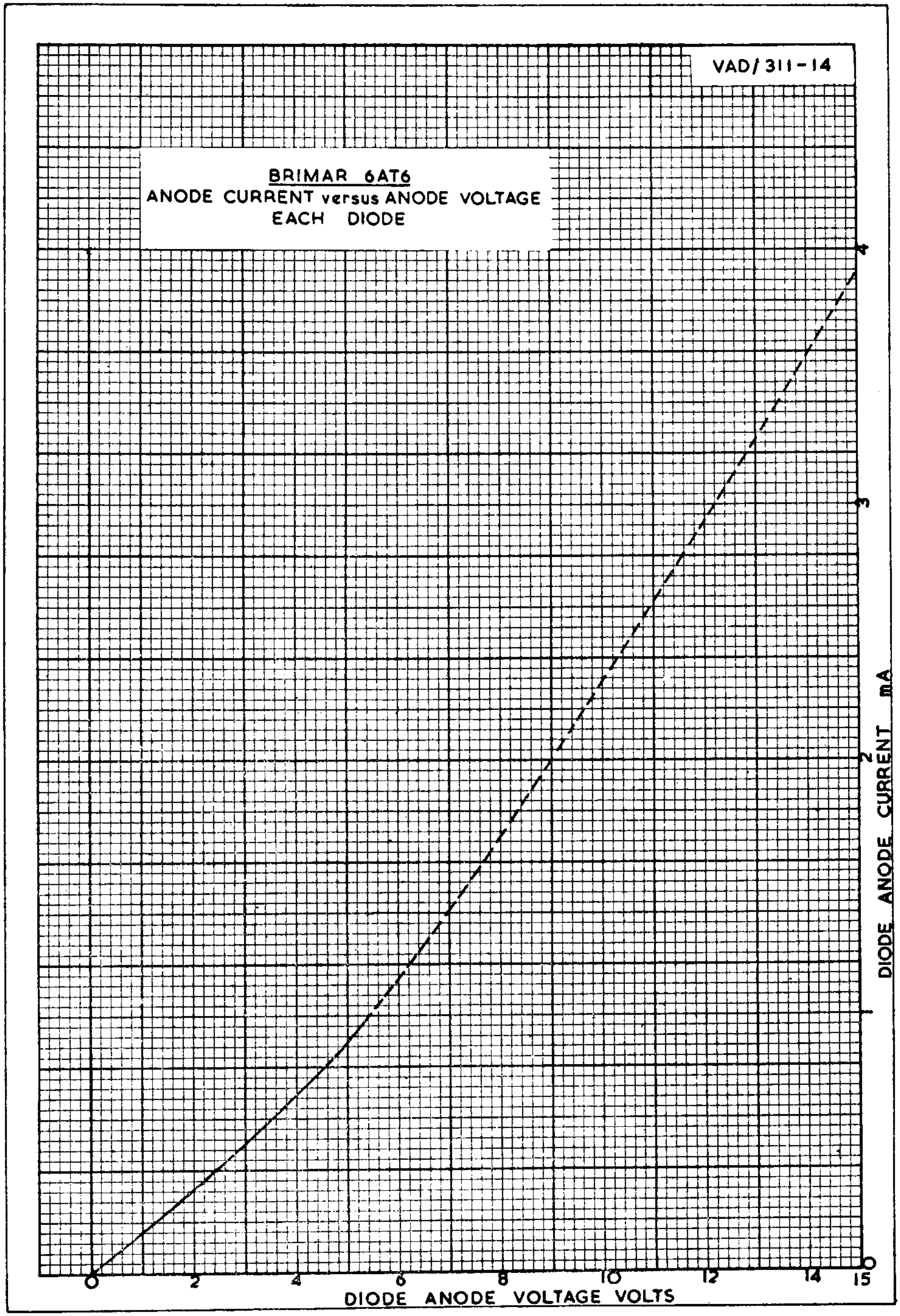


BRIMAR 6AT6
ANODE CURRENT versus ANODE VOLTAGE
TRIODE SECTION
GRID VOLTAGE Vg = O VOLTS
-1
-2
-3
-4
-5
-6
-7
ANODE CURRENT mA
10
7·5
5
2·5
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VAD/311-11

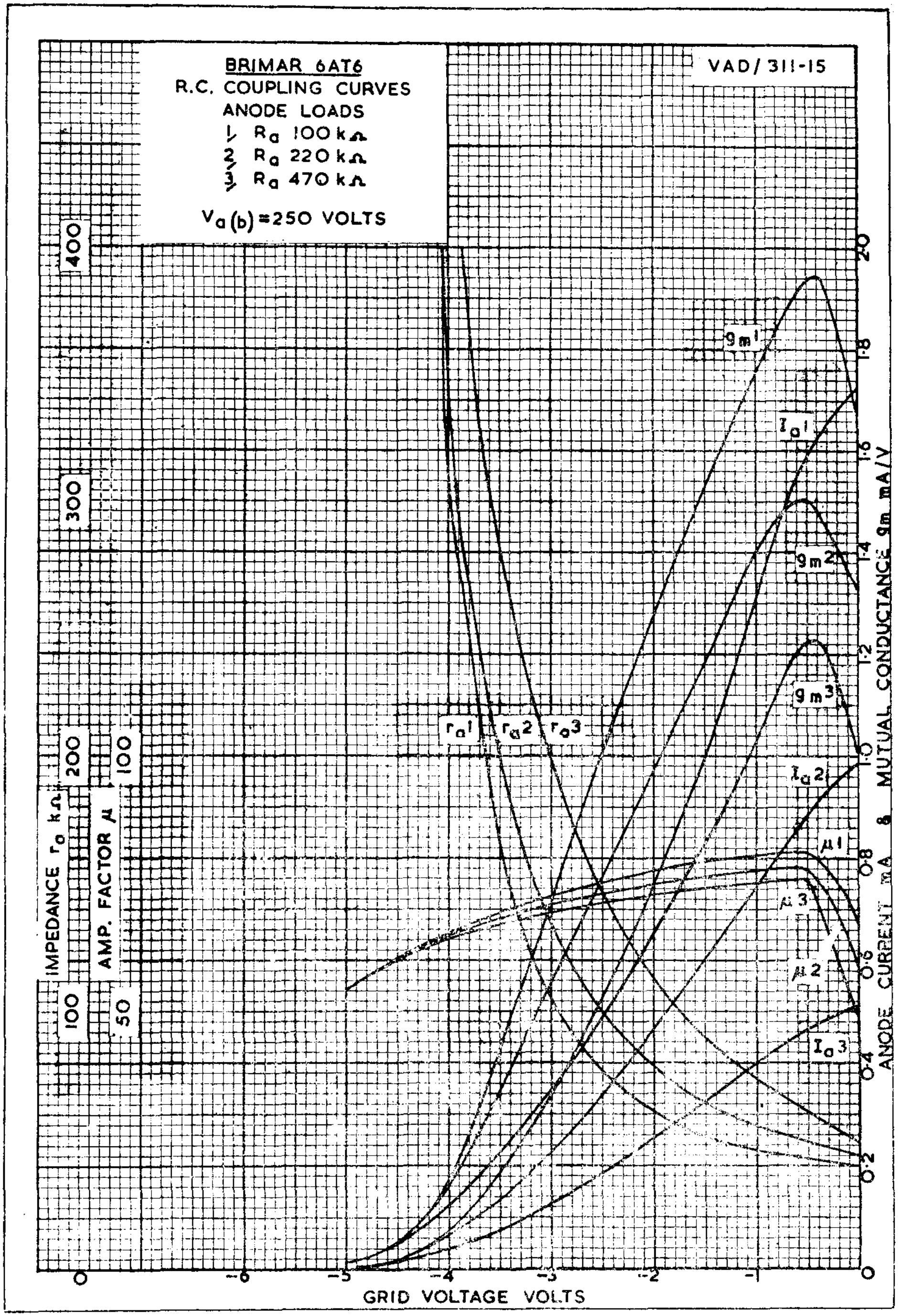

VAD/311-12
BRIMAR 6AT6
ANODE CURRENT versus GRID VOLTAGE
ANODE VOLTAGE Va = 400 VOLTS
300
200
100
10
7.5
5
2.5
0
ANODE CURRENT mA
−7
−6
−5
−4
−3
−2
−1
0
GRID VOLTAGE VOLTS



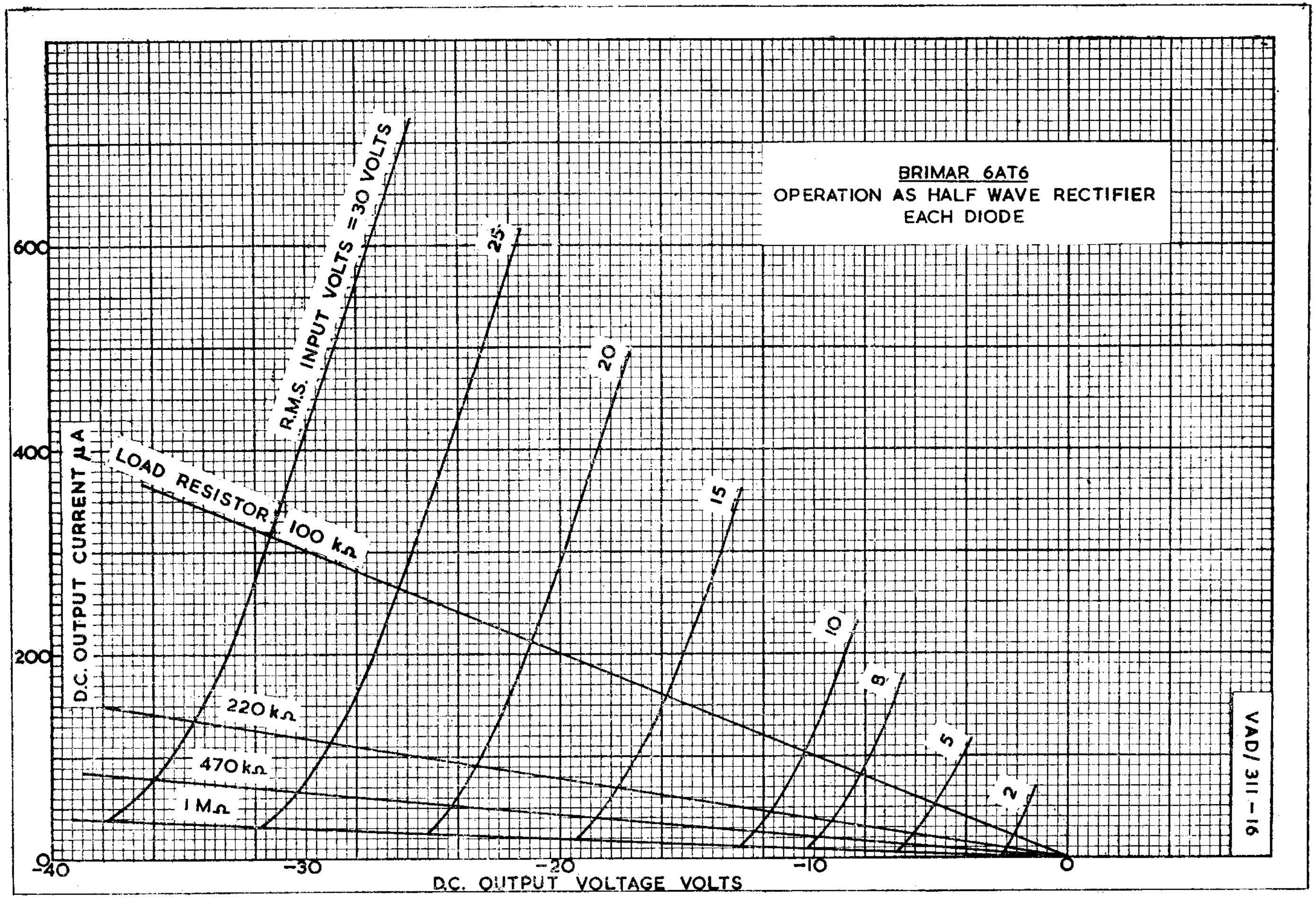
VAD/311-13
BRIMAR 6AT6
ANODE VOLTAGE Va = 250 VOLTS
IMPEDANCE r_a kΩ
200
150
100
50
0
AMPLIFICATION FACTOR μ
80
70
60
3
2
1
0
MUTUAL CONDUCTANCE g_m mA/V
μ
g_m
r_a
1
2
3
ANODE CURRENT mA



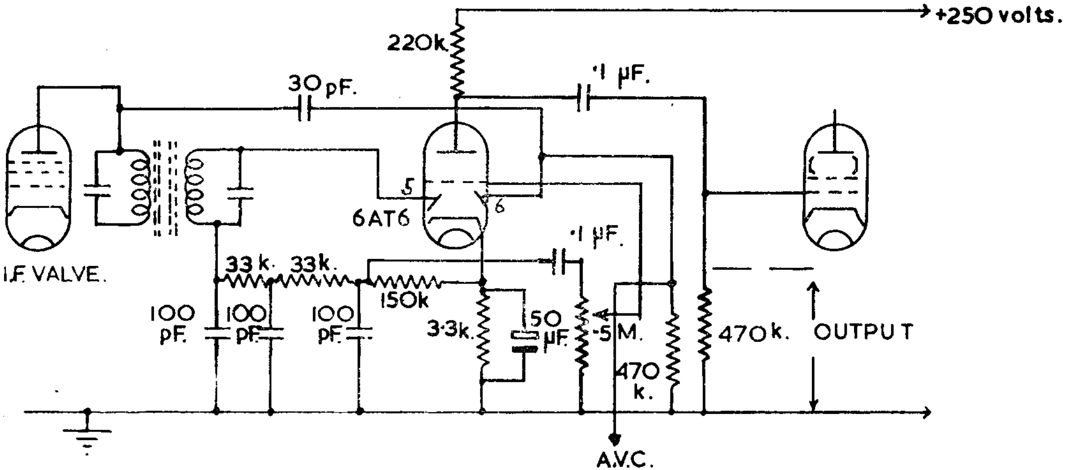
VAD/311-14
BRIMAR 6AT6
ANODE CURRENT versus ANODE VOLTAGE
EACH DIODE
DIODE ANODE CURRENT mA
0
2
3
4
0
2
4
6
8
10
12
14
15
DIODE ANODE VOLTAGE VOLTS



BRIMAR 6AT6
R.C. COUPLING CURVES
ANODE LOADS
1, Ra 100 kΩ
2, Ra 220 kΩ
3, Ra 470 kΩ
Va(b) = 250 VOLTS
VAD/311-15
IMPEDANCE ra kΩ
AMP. FACTOR μ
MUTUAL CONDUCTANCE gm mA/V & ANODE CURRENT mA
GRID VOLTAGE VOLTS
gm1
gm2
gm3
Ia1
Ia2
Ia3
μ1
μ2
μ3
ra1
ra2
ra3


BRIMAR 6AT6
OPERATION AS HALF WAVE RECTIFIER
EACH DIODE
R.M.S. INPUT VOLTS = 30 VOLTS
25
20
15
10
8
5
2
LOAD RESISTOR 100 kΩ
220 kΩ
470 kΩ
1 MΩ
D.C. OUTPUT CURRENT µA
600
400
200
0
-40
-30
-20
-10
0
D.C. OUTPUT VOLTAGE VOLTS
VAD/ 311 – 16

BRIMAR 6AT6 COMBINED DETECTOR & A.F. AMPLIFIER



FREQUENCY 465 kc/s.

BRIMAR

RECEIVING VALVE

6AU6

APPLICATION REPORT VAD/508.1

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

Issued January, 1949. Reprinted January, 1952.

INTRODUCTION: The Brimar valve type 6AU6 is an indirectly heated RF pentode. The heater is intended for operation in parallel with other valves in AC operated equipment. The valve is designed for use as an RF or IF amplifier, suitable shielding and short leads provide a good performance in high frequency circuits. This report contains characteristics of the valve and details of its performance.

DESCRIPTION: The valve consists of a miniature RF pentode having a mutual conductance of the order of 5 mA/V and is mounted in a standard T5½ bulb and fitted with a B7G standard base.

CHARACTERISTICS:

Cathode:	Indirectly heated	
	Voltage	6·3 volts
	Current (nominal)	0·3 ampere
	Max. DC Heater-Cathode potential	250 volts
Dimensions:	Max. Overall Length	2-1/8 ins.
	Max. Diameter	3/4 in.
	Max. Seated Height (excluding tip)	1-19/32 ins.
Base:	Type B7G	
Basing Connections:	Pin 1 Control Grid g_1	
	Pin 2 Suppressor Grid g_3 and Internal Shield	
	Pin 3 Heater	
	Pin 4 Heater	
	Pin 5 Anode	
	Pin 6 Screen Grid g_2	
	Pin 7 Cathode	

Ratings:

PENTODE CONNECTIONS:

Max. Anode Voltage	300 volts
Max. Screen Voltage	150 volts
Max. Screen Supply Voltage	300 volts
Max. Anode Dissipation	3·0 watts
Max. Screen Dissipation	0·65 watt

TRIODE CONNECTION (Pins 2, 5 and 6 strapped)

Max. Anode Voltage	250 volts
Max. Anode Dissipation	3·2 watts

Capacities (approx.):*

PENTODE CONNECTED:

c Input	5·5 pF
c Output	5·0 pF
$c_{g1,a}$	0·0035 pF max.

TRIODE CONNECTED:

c Input	3·1 pF
c Output	1·7 pF
$c_{g1,a}$	2·5 pF

* Measured with no external shield.

GROUNDED GRID OPERATION:

Anode, Cathode	0·013 pF
Input	6·1 pF
Output	5·4 pF

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

Anode current plotted against control grid voltage for various screen voltage (I_a/V_{g1}) (Curve No. 308·32).

Mutual conductance and anode impedance against control grid voltage (g_m/V_{g1}) (R_a/V_{g1}) (Curve No. 308·33).

Anode current plotted against anode voltage (I_a/V_a) for a screen voltage of 150 volts (Curve No. 308·34) and for a screen voltage of 100 volts (Curve No. 308·35).

Anode current plotted against anode voltage (I_a/V_a) connected as a triode (Curve No. 308·36).

TYPICAL OPERATION

CLASS "A" AMPLIFIER:

Pentode connected (g_3 connected to cathode):

Heater Voltage	6·3	6·3	6·3	volts
Anode Voltage	100	250	250	volts
Screen Voltage	100	125	150	volts
Grid Voltage	—1	—1	—1	volts
Cathode Bias Resistor	140	100	68	ohms
Anode Current	5·2	7·6	10·8	mA
Screen Current	2·0	3·0	4·3	mA
Anode Impedance (r_a)	0·5	1·5	1·0	megohms
Mutual Conductance (g_m)	3·9	4·45	5·2	mA/V
Inner Amplification Factor (μ_{g1g2})	39	40	41	
Grid Voltage for 1/100 g_m at V_g = —1	—4·5	—5·5	—6·35	volts
Suppressor Grid Voltage for 1/100 g_m at V_{g3} = 0	—38	—81	—90	volts
Equivalent Noise Resistance (R_{eg})	2350	2350	2600	ohms
Input Impedance at 45 Mc/s	4200	3700	3400	ohms
Input Impedance at 90 Mc/s	950	920	900	ohms

Triode Connected:

Heater Voltage	6·3	volts
Anode Voltage	250	volts
Grid Voltage	—4	volts
Amplification Factor	36	
Anode Impedance	7500	ohms
Mutual Conductance	4·8	mA/V
Anode Current	12·2	mA

OPERATION AS AN RF OR IF AMPLIFIER:

The valve is very suitable for service in the above application. It is recommended that cathode bias be always used rather than fixed bias and that normally the suppressor grid (g_3) and the internal shield be connected to the cathode at the socket.

The valve socket should be so mounted that the grid and anode leads to the remainder of the circuit run in opposite directions to each other and are as short as is practicable in order to ensure high gain with stability. The decoupling components should also be chosen and located with care for similar reasons.

When used in VHF receivers the valve may be employed with normal pentode connections or as a grounded grid amplifier at frequencies of the order of 100 Mc/s. It is also very efficient as an IF amplifier using intermediate frequencies around 10 Mc/s. When so employed a stage gain of 47 times can be expected with a total bandwidth of 200 Kc/s for 3 dB down with IF coils of Q 70 and tuning capacity 50 pF.

For those applications where very high frequencies are employed and changes in input capacity, and input impedance are undesirable, it is advised that grid bias is applied to the control grid and suppressor grid simultaneously, the control grid being biased to a value of approximately 2% of that applied to the suppressor grid.

Curves are attached to this report as follows:

Input capacity and input impedance plotted against control grid voltage for the sliding screen conditions at 50 Mc/s (Curve No. 308·38) similarly but for autobias (Curve No. 308·39) input capacity and input impedance against suppressor grid voltage (V_{g3}) at 50 Mc/s with control grid voltage 2% of V_{g3} (Curve No. 308·40). Curves Nos. 308·41, ·42 and ·43 are similar to the above but taken at a frequency of 90 Mc/s.

OPERATION AS A RESISTANCE-CAPACITY COUPLED AMPLIFIER:

Pentode Connected: The valve is very suitable for use as an RC coupled amplifier and below is a table giving a summary of useful values at two different supply voltages for a distortion of approximately 5% harmonic:

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

Anode Load (R_a megohms)	0·1		0·22		0·47	
Series Screen Resistor (R_{g2} megohms)	0·09		0·25		0·75	
Grid Leak (succeeding valve) (megohms)	0·22	0·47	0·22	0·47	0·47	1·0
Cathode Resistor (ohms)	2100	2100	3300	3300	6400	6400
Output Voltage (peak)	32	37	25	32	27	32
Voltage Gain	72	88	72	100	100	125

b. Anode Supply Voltage $V_{a(b)}$ —300 volts:

Anode Load (R_a megohms)	0·1		0·22		0·47	
Series Screen Resistor (R_{g2} megohms)	0·25		0·5		1·0	
Grid Leak (succeeding valve) (megohms)	0·22	0·47	0·22	0·47	0·47	1·0
Cathode Resistor (ohms)	600	700	1000	1000	1800	1800
Output Voltage (peak)	103	130	892	108	94	105
Voltage Gain	145	170	164	230	250	320

Curves are attached to this report showing the characteristics when used under RC coupled amplifier conditions at an HT line voltage of 250 volts. Curve No. 308·29 is plotted with an anode load resistor of 470,000 ohms and shows the relation between anode, current, screen current and control grid voltage for various screen voltages. Curves Nos. 308·30 and ·31 are similar to the above but plotted with anode load resistors of 220,000 and 100,000 ohms respectively. The method of using these curves to design an RC coupled amplifier is described below.

If for example it is desired to use the valve at a supply voltage ($V_{a(b)}$) of 250 volts with an anode load resistor of 220,000 ohms and a succeeding valve grid leak of 470,000 ohms, then an examination of the Curve No. 308·30 shows that grid current (I_{g1}) commences at about —1 volts, hence a grid bias should be chosen such that the signal never swings the grid to a value of less than —1 volt. If a value of 1·5 volts is taken, then fairly straight portions of the I_a/V_{g1} curves are available for V_{g2} 50 volts. Taking the operating point as V_{g2} 50 volts and V_{g1} —1·5 volts, the anode current will be 0·54 mA and the screen current I_{g2} 0·27 mA, hence the cathode resistor will be $\frac{1 \cdot 5 \times 1000}{0 \cdot 54 + 0 \cdot 27}$ or 1850 ohms. The screen dropping resistor would be $\frac{250 - 50}{0 \cdot 27}$ or 0·75 megohms. If the grid has a peak AF input of $\pm 0 \cdot 3$ volts as a maximum, the anode current will vary from 0·24 mA at a grid voltage of 1·8 volts to 0·94 mA at 1·2 volts, hence a change of 0·70 mA in 220,000 ohms is 154 volts peak-peak. This is an output of 77 volts peak and a voltage gain of $\frac{77}{0 \cdot 3}$ or 257. As allowance must be made for the succeeding valve grid leak, the above values will be reduced by a factor of $\frac{470{,}000}{470{,}000 + 220{,}000}$ or 0·68, hence the actual operating gain will be 175 and the output voltage 17·5 volts peak for an input of 0·1 volts peak. An estimate of the distortion can be obtained by calculating in a similar manner the voltage gain for the positive swing 1·5 to 1·2 volts and the negative swing 1·5 to 1·8 volts separately the resultant figures indicating the amount by which one peak is amplified more than the other.

Triode Connected: The valve may be used as a triode R-C coupled amplifier, and a graph is attached to this report showing the relation between the various valve parameters under conditions of resistance coupling. This graph (No. 308·37) is taken at an anode supply voltage ($V_{a(b)}$) of 250 volts with three values of anode load resistor, viz., 47,000, 100,000 and 220,000 ohms and plots the anode current, amplification factor, mutual conductance and anode impedance against grid voltage. From this graph the correct grid bias (cathode resistor) can be obtained, also 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, and anode load of 220,000 ohms and a succeeding valve grid leak of 470,000 ohms, then to determine the grid bias an inspection of the graph indicates a relatively linear portion of the curve of anode current/grid volts over the range of —1 to —6 volts, the mid point being —3·5 volts. At this point the anode current is 0·67 mA hence the cathode resistance should be 520 ohms. The peak input voltage is 2·5 volts and the R.M.S. input 1·75 volts. Following the grid bias voltage upward on the curve it is evident that with an anode load of 220,000 ohms, the amplification factor (μ) is 29, and the anode impedance is 26,000 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 220,000 ohms in parallel with 470,000 ohms or is 150,000 ohms. The stage gain is:

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

or in the above case:

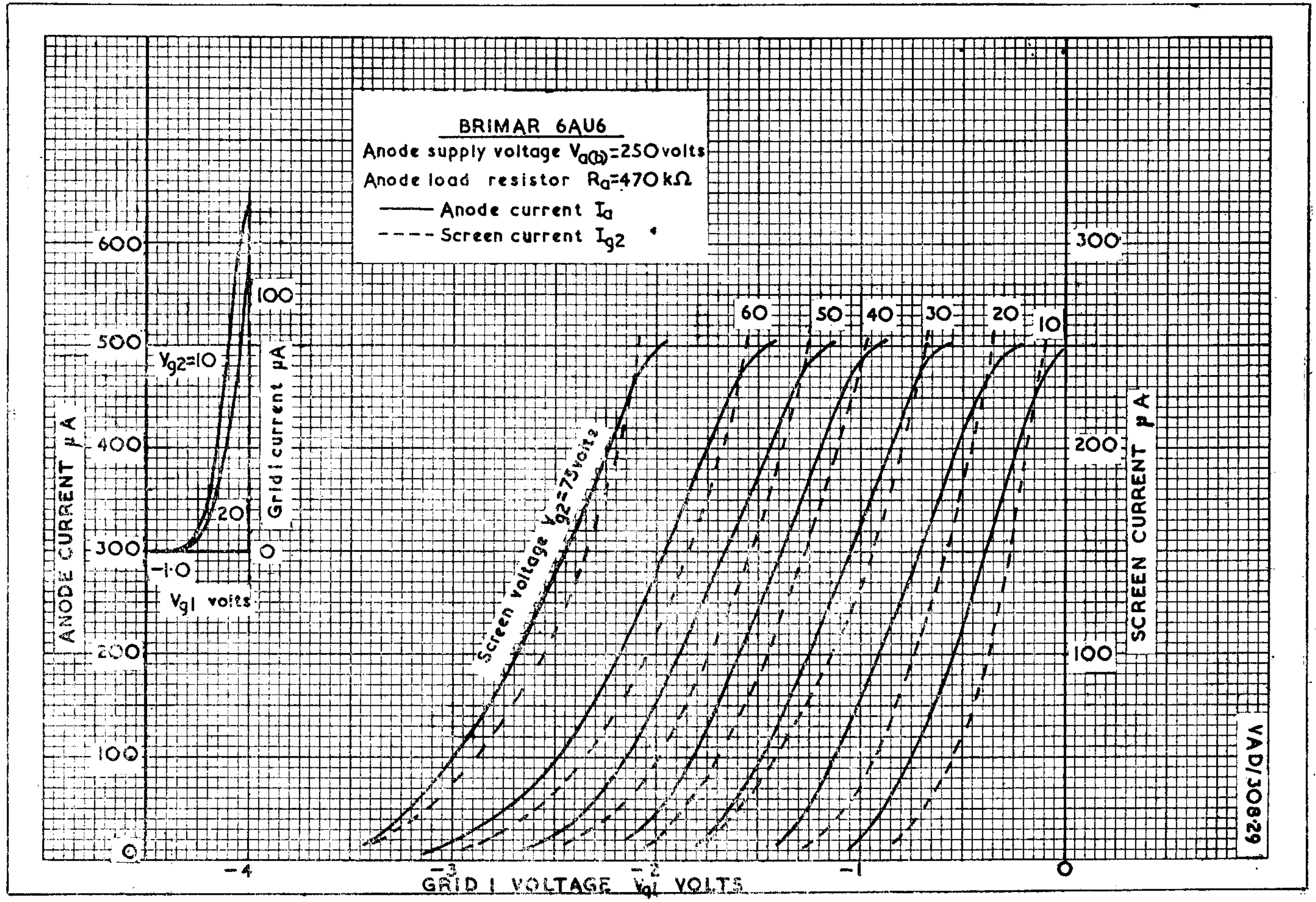
$$\frac{29 \times 150{,}000}{150{,}000 + 26{,}000} = 25$$

The peak input voltage above was 2·5 volts hence the peak output voltage will be this figure multiplied by the stage gain or 62 volts or 44 volts R.M.S.

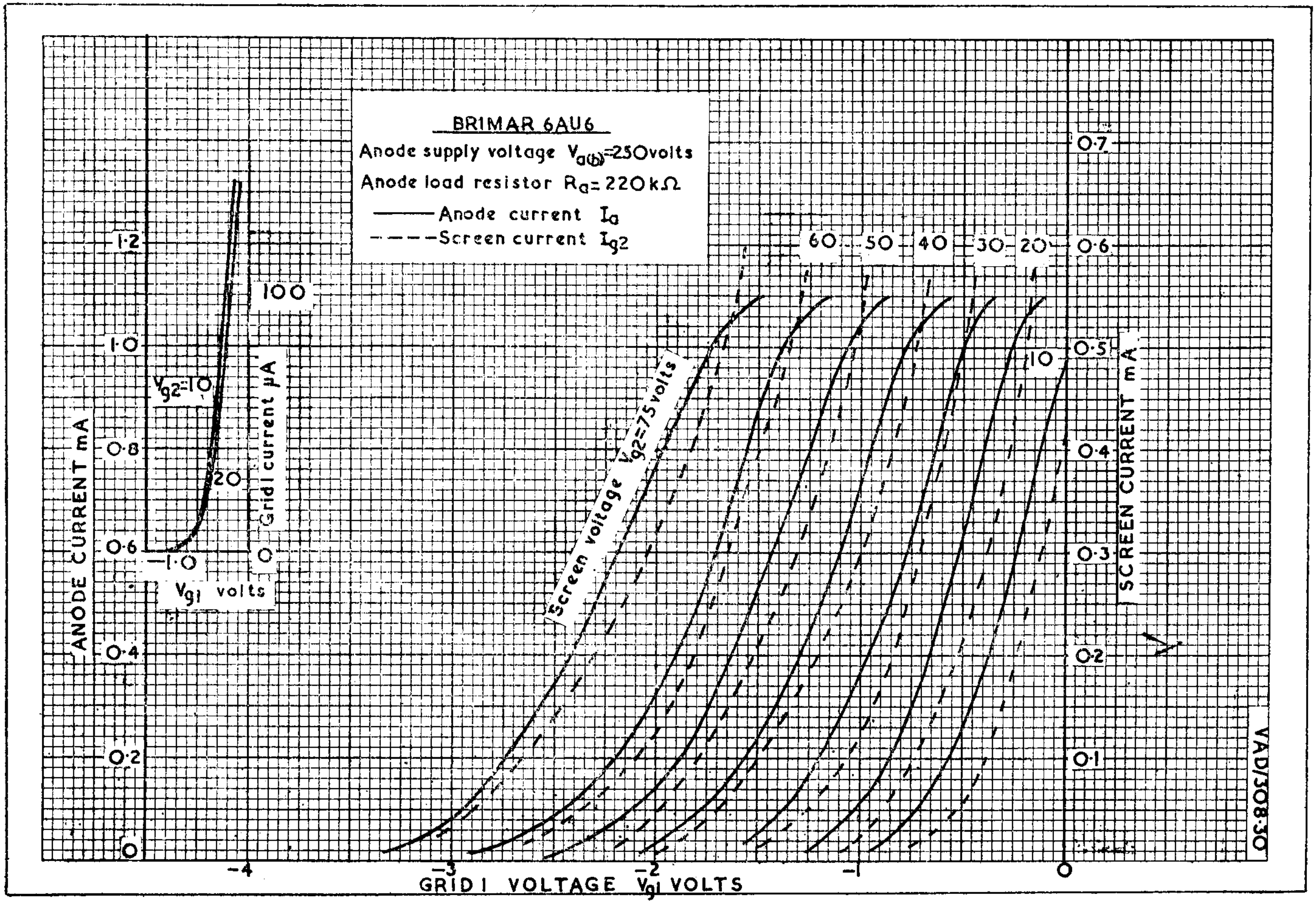
An estimate of the distortion may be made by calculating from the graph as above the stage gain at the extremes of grid bias; in the example the stage gain at —1 volts is 30 and at —6 volts is 20, hence the positive peaks of the signal output will be less than the negative.

OPERATION AS AN FM LIMITER:

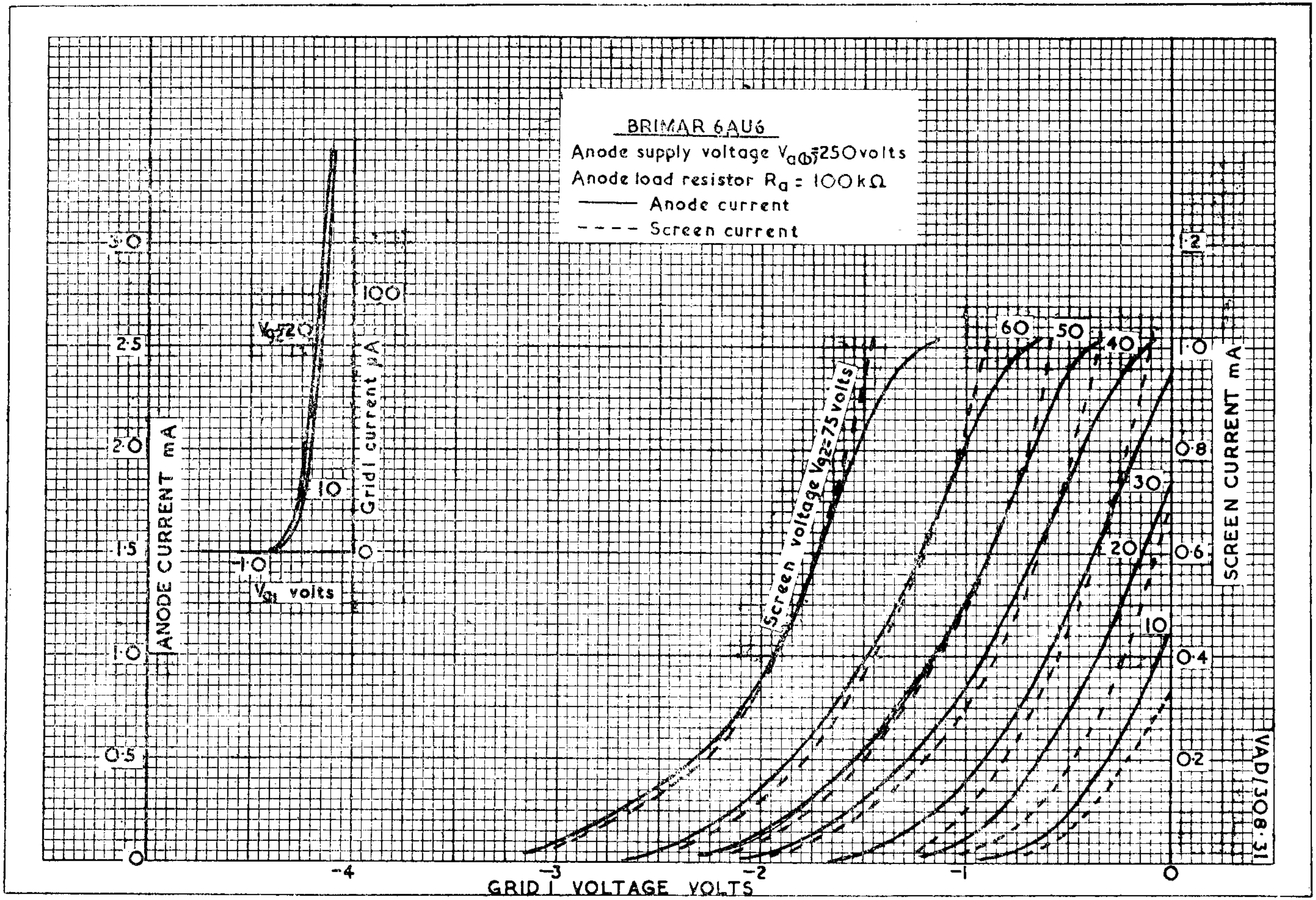
The high slope and short grid base make the valve very suitable for use as a limiter for FM receivers. A curve (No. 308·46) attached to this report, shows the operation as a limiter for two different conditions, Curve No. 1 threshold at 1 volt, and Curve No. 2 for 0·5 volts, the output being approximately 10 volts and 6 volts respectively.

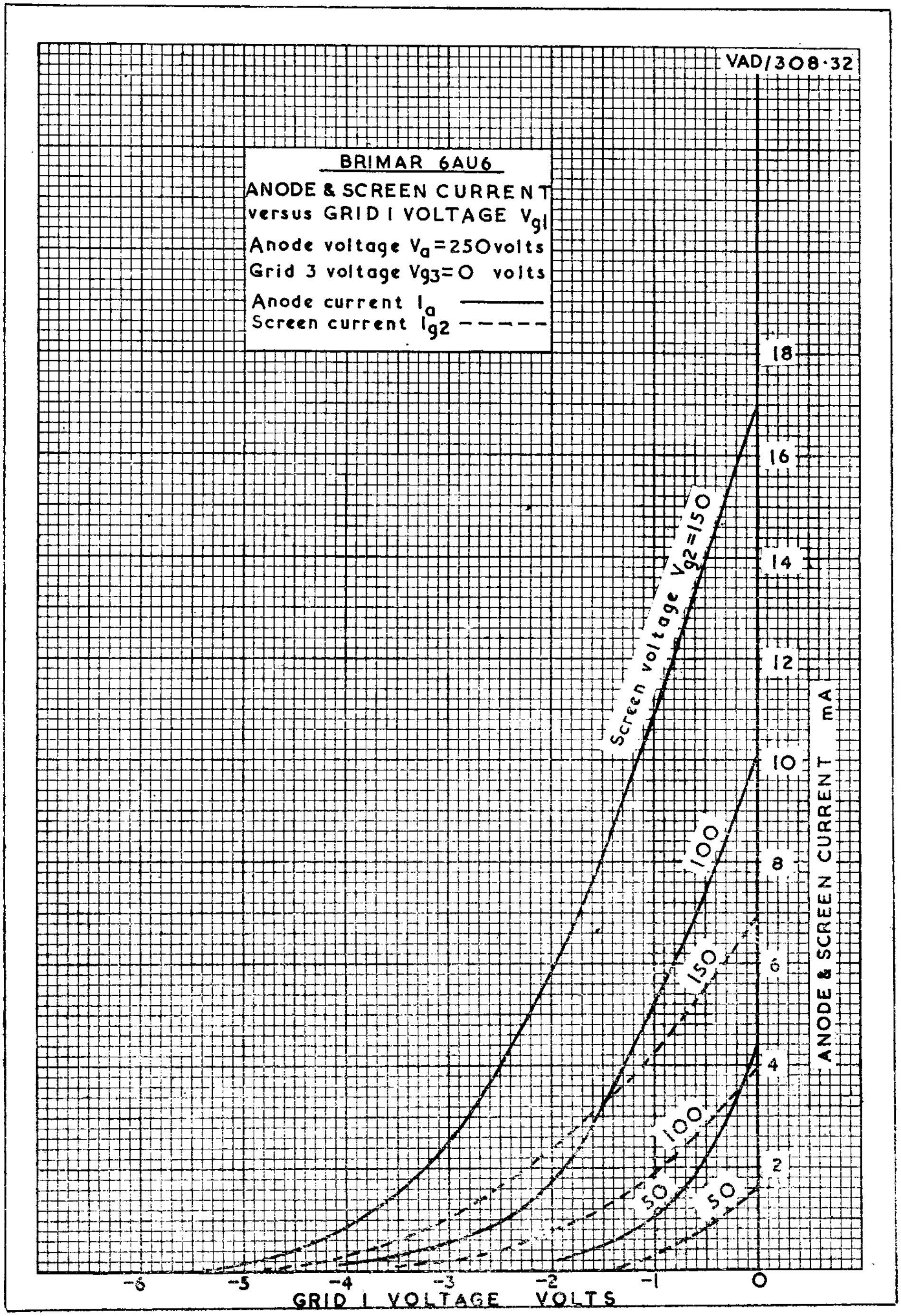


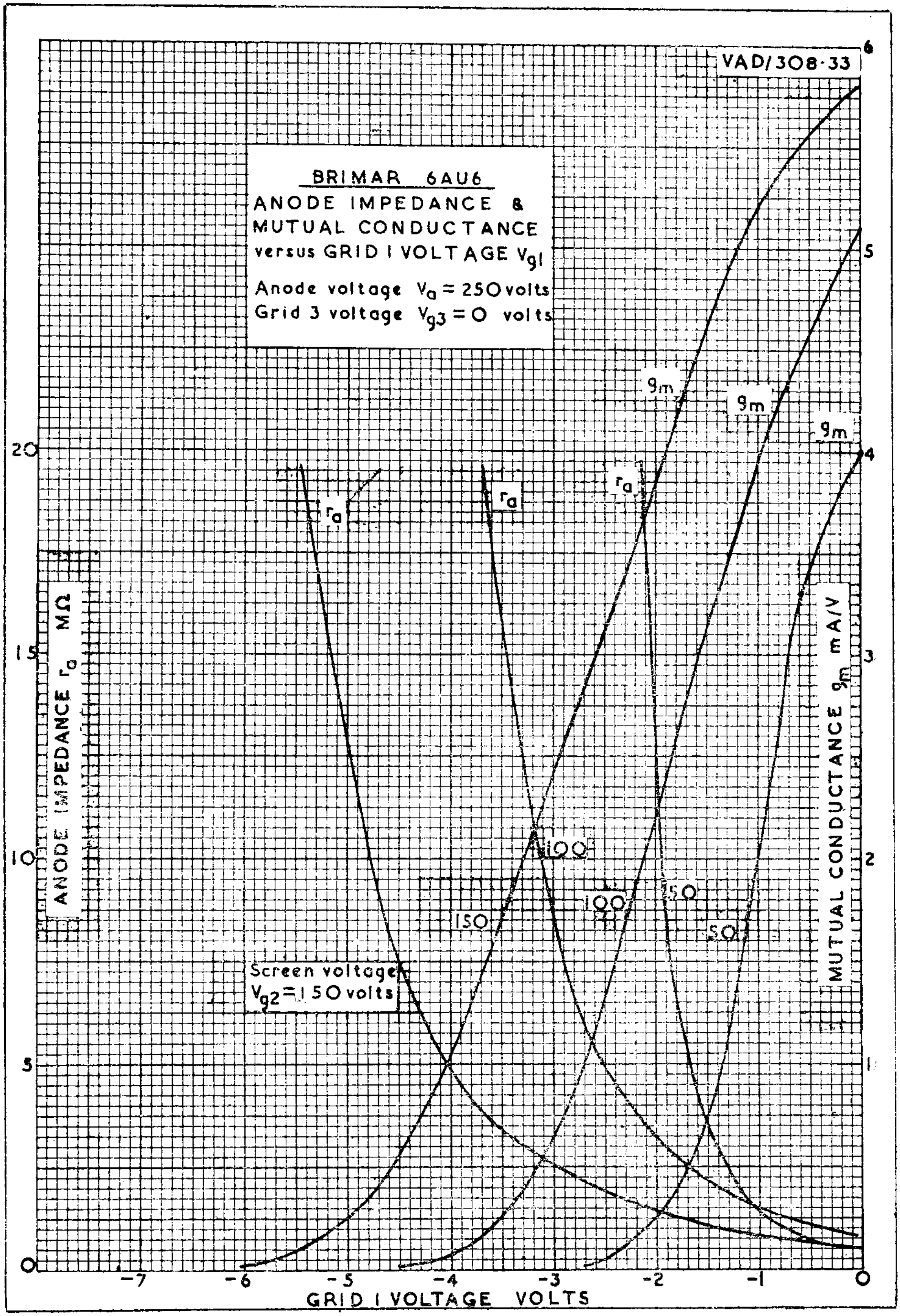
BRIMAR 6AU6
Anode supply voltage $V_{a(b)}$=250 volts
Anode load resistor R_a=470 kΩ
Anode current I_a
Screen current I_{g2}
ANODE CURRENT µA
SCREEN CURRENT µA
GRID I VOLTAGE V_{g1} VOLTS
Grid I current µA
V_{g1} volts
V_{g2}=10
Screen voltage V_{g2}=75 volts
10
20
30
40
50
60
0
100
200
300
400
500
600
−1
−2
−3
−4
−1·0
VAD/308·29

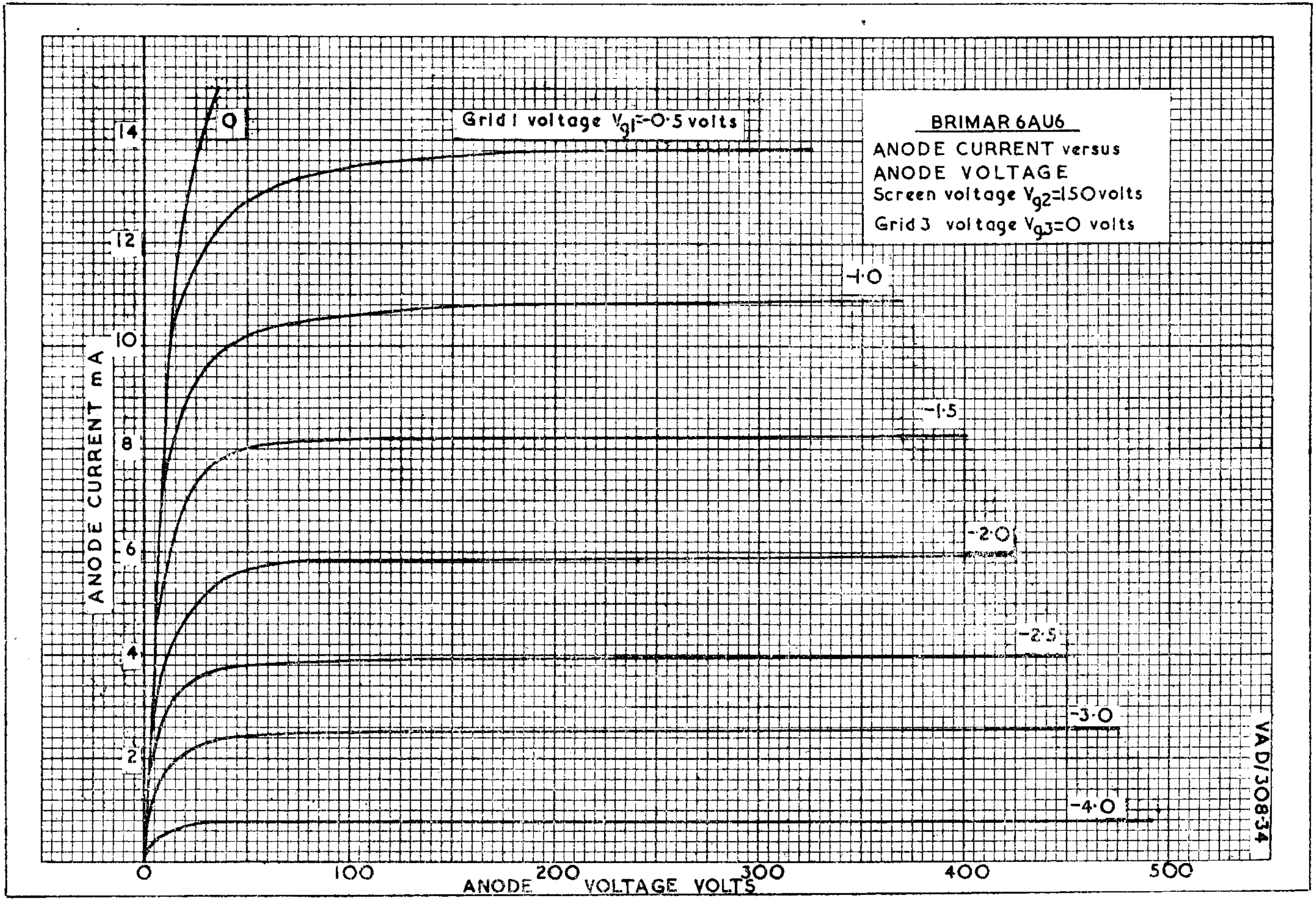


BRIMAR 6AU6
Anode supply voltage $V_{a(b)}$=250 volts
Anode load resistor R_a= 220 kΩ
Anode current I_a
Screen current I_{g2}
Screen voltage V_{g2}=75 volts
60 50 40 30 20 10
ANODE CURRENT mA
SCREEN CURRENT mA
GRID1 VOLTAGE V_{g1} VOLTS
Grid current µA
V_{g1} volts
V_{g2}=10
100
20
−1·0
1·2
1·0
0·8
0·6
0·4
0·2
0
0·7
0·6
0·5
0·4
0·3
0·2
0·1
−4
−3
−2
−1
0
VAD/308·30

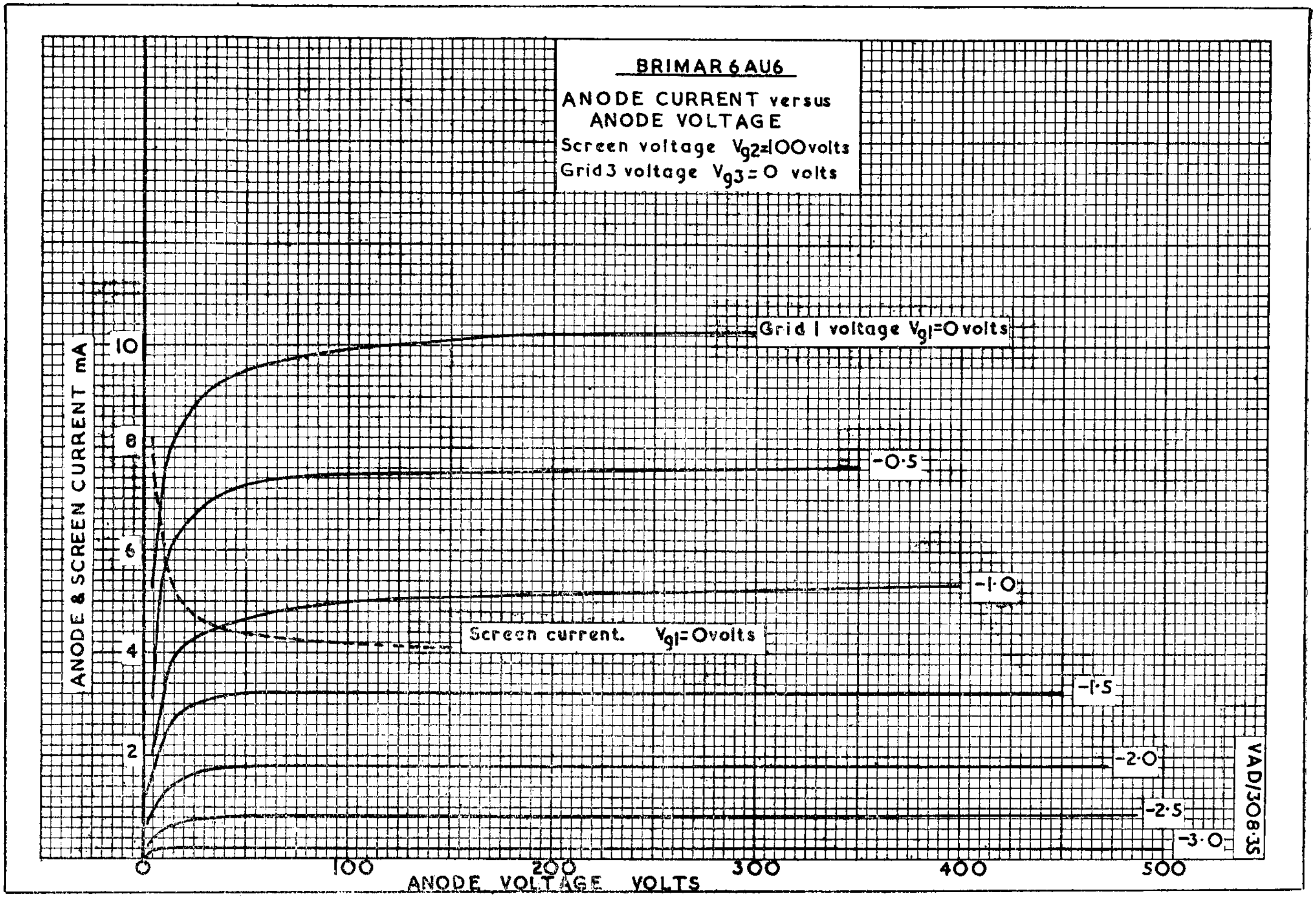

BRIMAR 6AU6
Anode supply voltage $V_{a(b)}$=250 volts
Anode load resistor R_a = 100 kΩ
Anode current
Screen current
ANODE CURRENT mA
SCREEN CURRENT mA
GRID 1 VOLTAGE VOLTS
Grid 1 current μA
V_{g1} volts
V_{g2}=20
Screen voltage V_{g2}=75 volts
60
50
40
30
20
10
3·0
2·5
2·0
1·5
1·0
0·5
0
1·2
1·0
0·8
0·6
0·4
0·2
0
-4
-3
-2
-1
0
100
10
0
-1·0
VAD/308·31

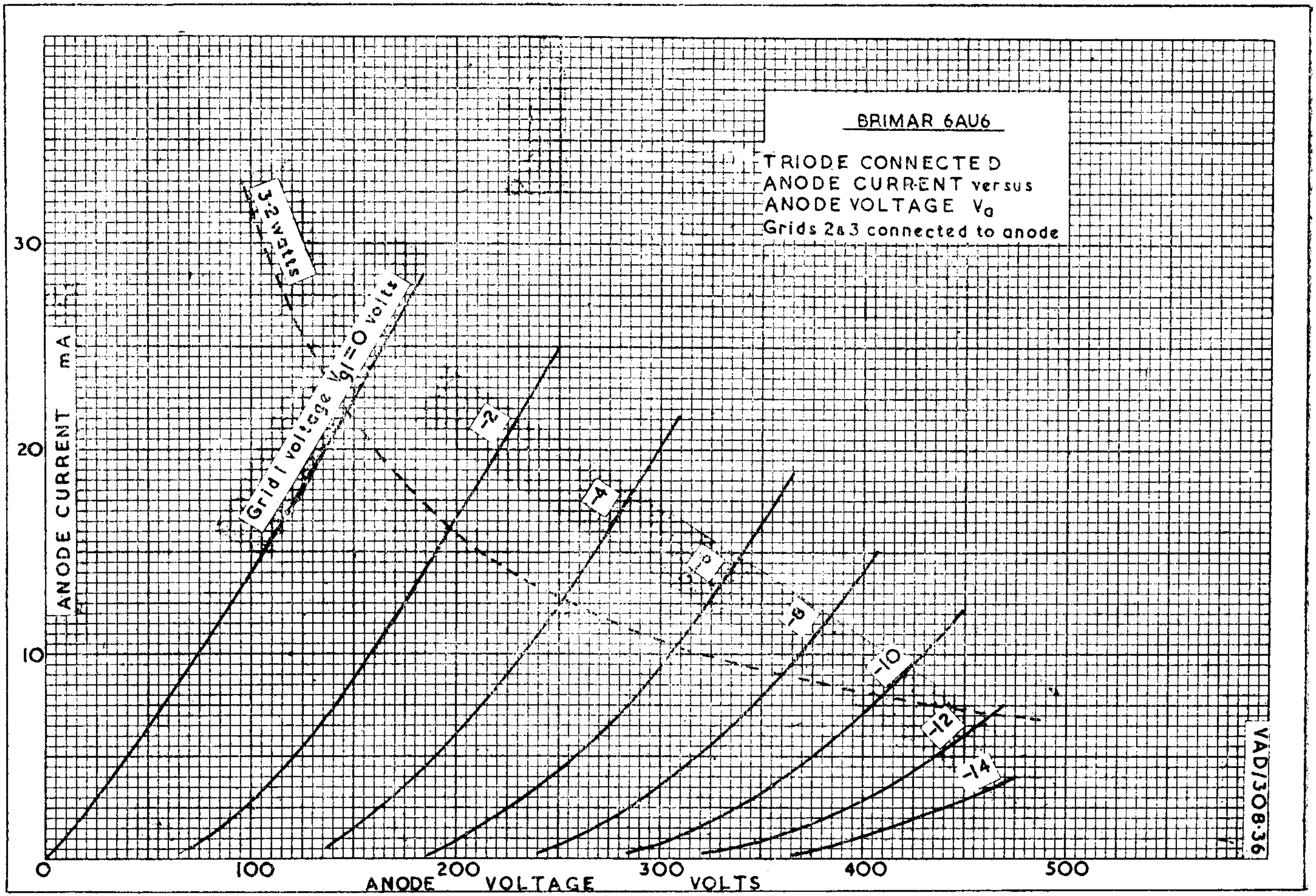

VAD/308·32
BRIMAR 6AU6
ANODE & SCREEN CURRENT
versus GRID I VOLTAGE V_{g1}
Anode voltage V_a=250 volts
Grid 3 voltage V_{g3}=0 volts
Anode current I_a
Screen current I_{g2}
Screen voltage V_{g2}=150
100
150
100
50
50
18
16
14
12
10
8
6
4
2
ANODE & SCREEN CURRENT mA
-6
-5
-4
-3
-2
-1
0
GRID I VOLTAGE VOLTS


VAD/308·33
BRIMAR 6AU6
ANODE IMPEDANCE & MUTUAL CONDUCTANCE versus GRID 1 VOLTAGE V_{g1}
Anode voltage V_a = 250 volts
Grid 3 voltage V_{g3} = 0 volts
Screen voltage V_{g2} = 150 volts
g_m
r_a
150
100
50
ANODE IMPEDANCE r_a MΩ
MUTUAL CONDUCTANCE g_m mA/V
GRID 1 VOLTAGE VOLTS
0
5
10
15
20
1
2
3
4
5
6
−7
−6
−5
−4
−3
−2
−1

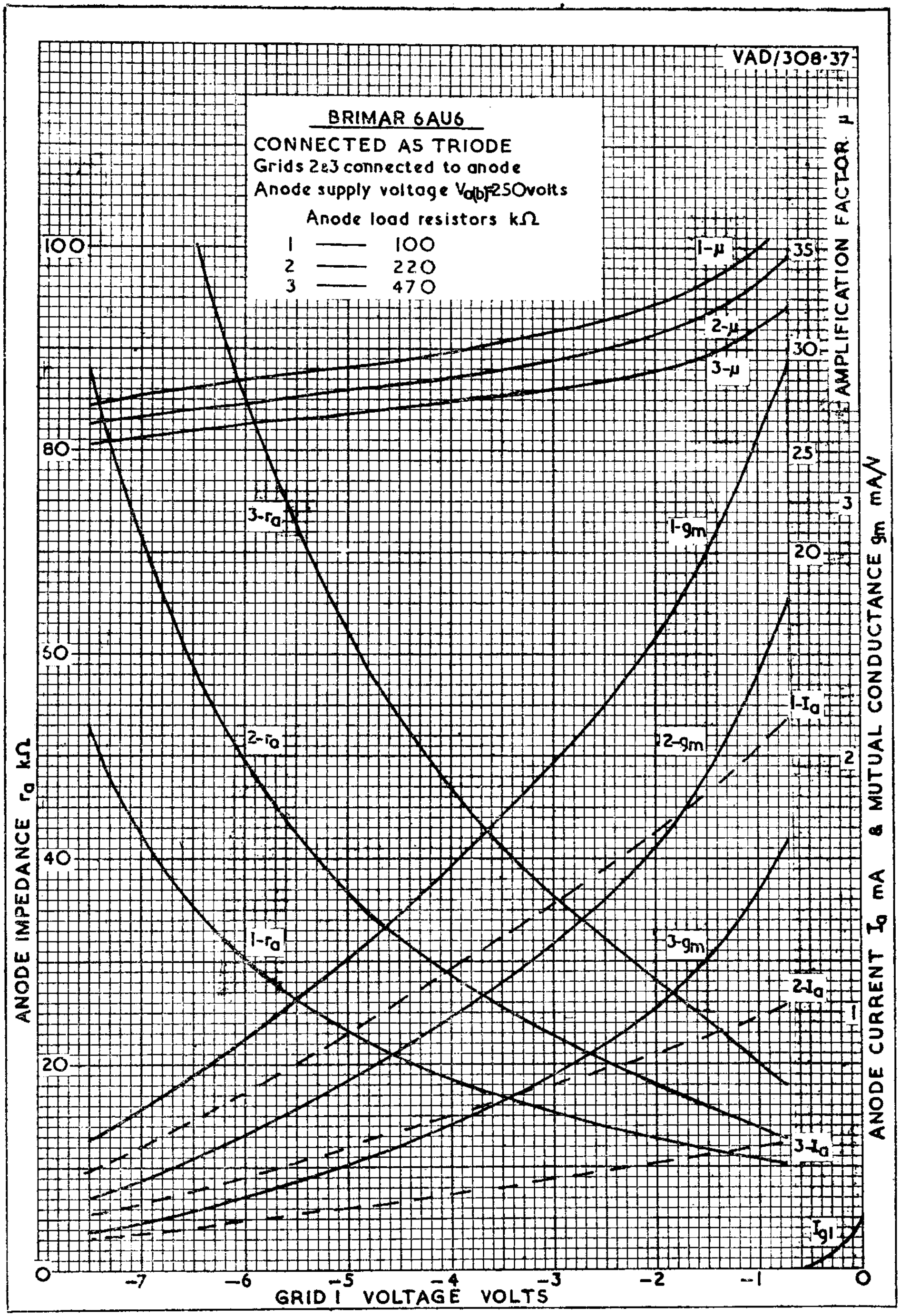


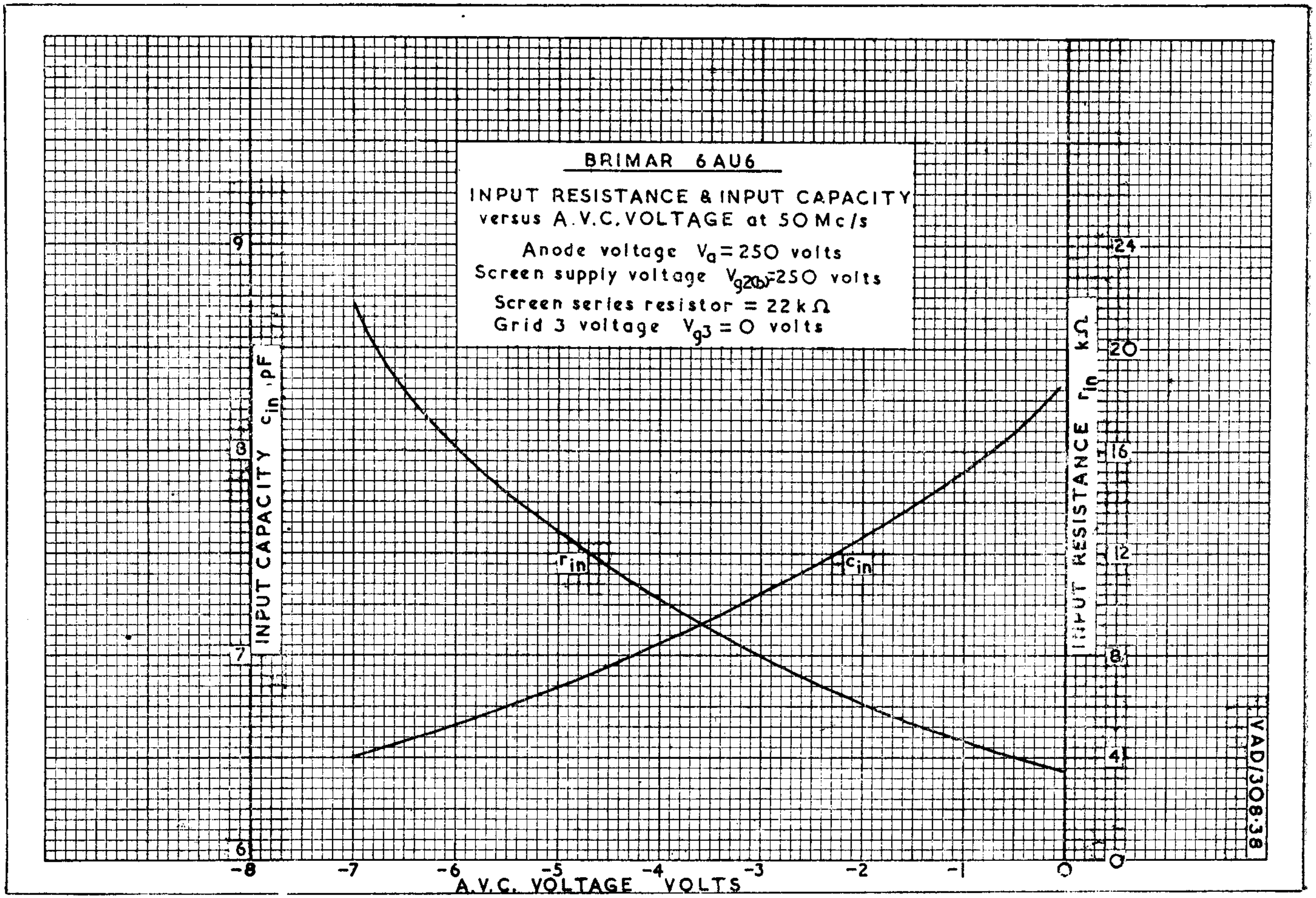
BRIMAR 6AU6
ANODE CURRENT versus
ANODE VOLTAGE
Screen voltage V_{g2}=150 volts
Grid 3 voltage V_{g3}=0 volts
Grid 1 voltage V_{g1}=-0·5 volts
0
-1·0
-1·5
-2·0
-2·5
-3·0
-4·0
ANODE CURRENT mA
14
12
10
8
6
4
2
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VAD/308·34

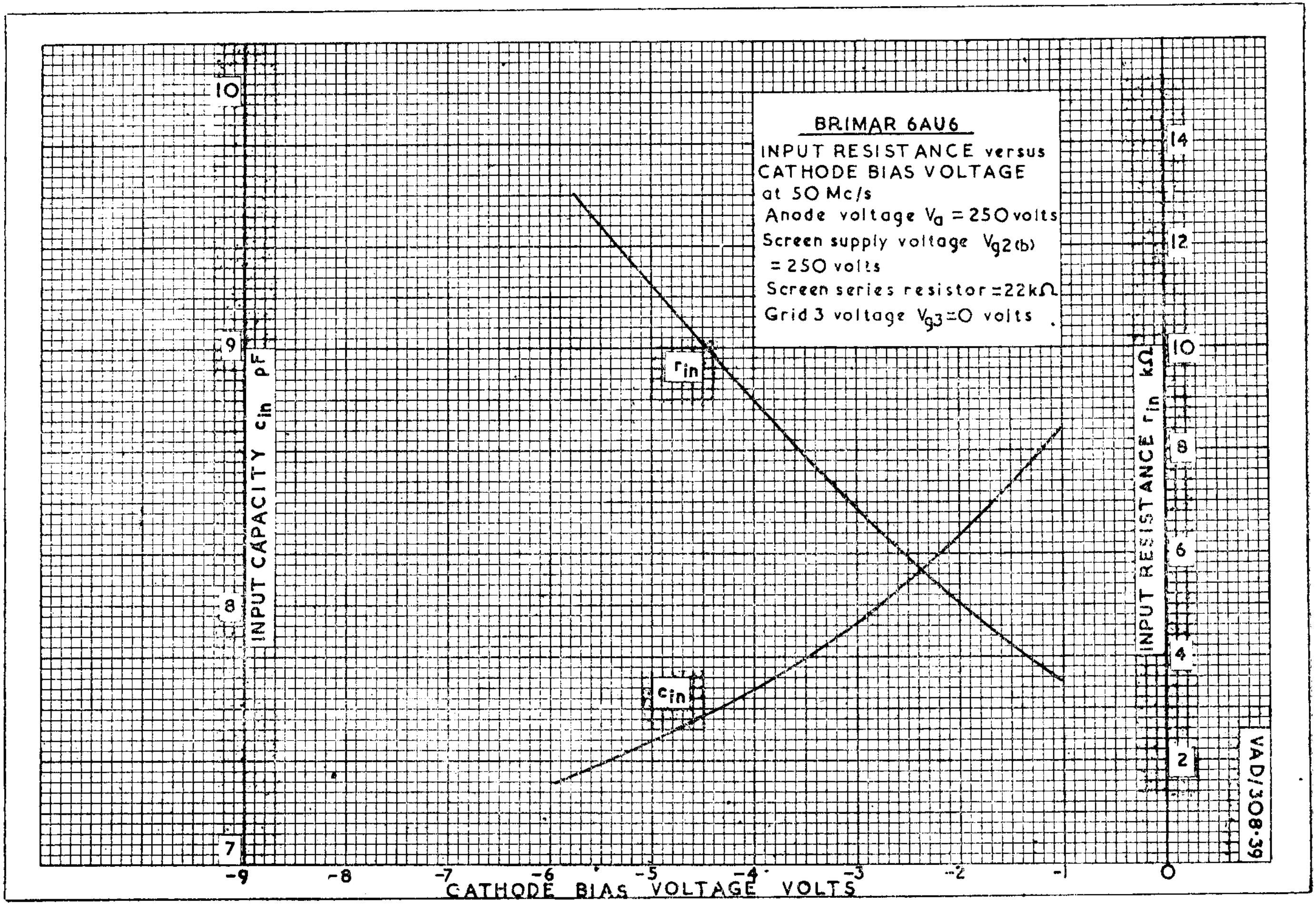

BRIMAR 6AU6
ANODE CURRENT versus ANODE VOLTAGE
Screen voltage V_{g2}=100 volts
Grid 3 voltage V_{g3}=0 volts
Grid 1 voltage V_{g1}=0 volts
-0·5
-1·0
-1·5
-2·0
-2·5
-3·0
Screen current. V_{g1}=0 volts
ANODE & SCREEN CURRENT mA
10
8
6
4
2
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VAD/308·35



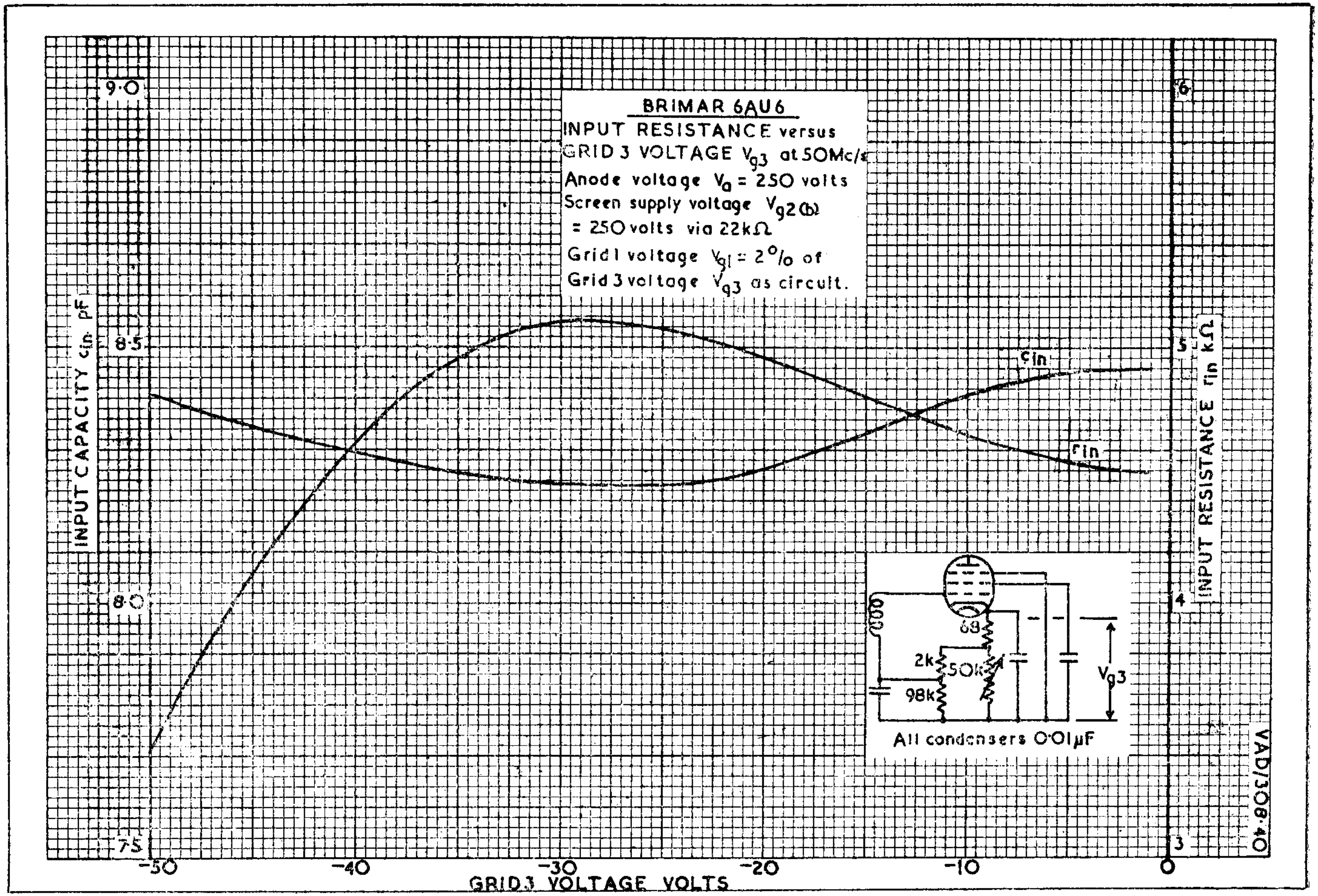
BRIMAR 6AU6
TRIODE CONNECTED
ANODE CURRENT versus
ANODE VOLTAGE V_a
Grids 2 & 3 connected to anode
3·2 watts
Grid I voltage V_{g1}=0 volts
-2
-4
-6
-8
-10
-12
-14
ANODE CURRENT mA
30
20
10
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VAD/308·36

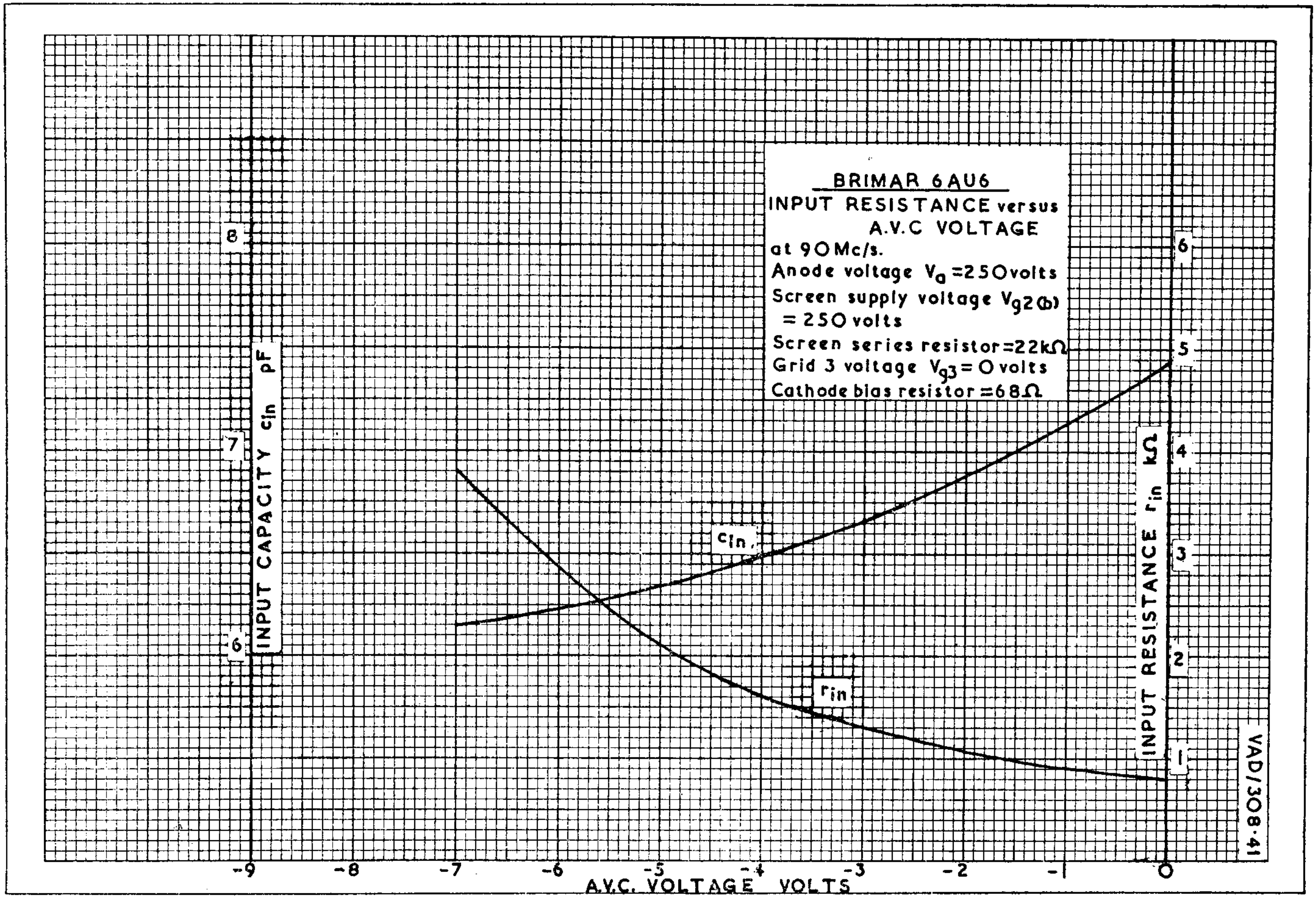

VAD/308·37
BRIMAR 6AU6
CONNECTED AS TRIODE
Grids 2&3 connected to anode
Anode supply voltage Va(b)=250 volts
Anode load resistors kΩ
1 —— 100
2 —— 220
3 —— 470
1-μ
2-μ
3-μ
3-ra
2-ra
1-ra
1-gm
2-gm
3-gm
1-Ia
2-Ia
3-Ia
Ig1
ANODE IMPEDANCE ra kΩ
AMPLIFICATION FACTOR μ
ANODE CURRENT Ia mA & MUTUAL CONDUCTANCE gm mA/V
GRID 1 VOLTAGE VOLTS
0
-7
-6
-5
-4
-3
-2
-1
0
20
40
60
80
100
1
2
3
20
25
30
35

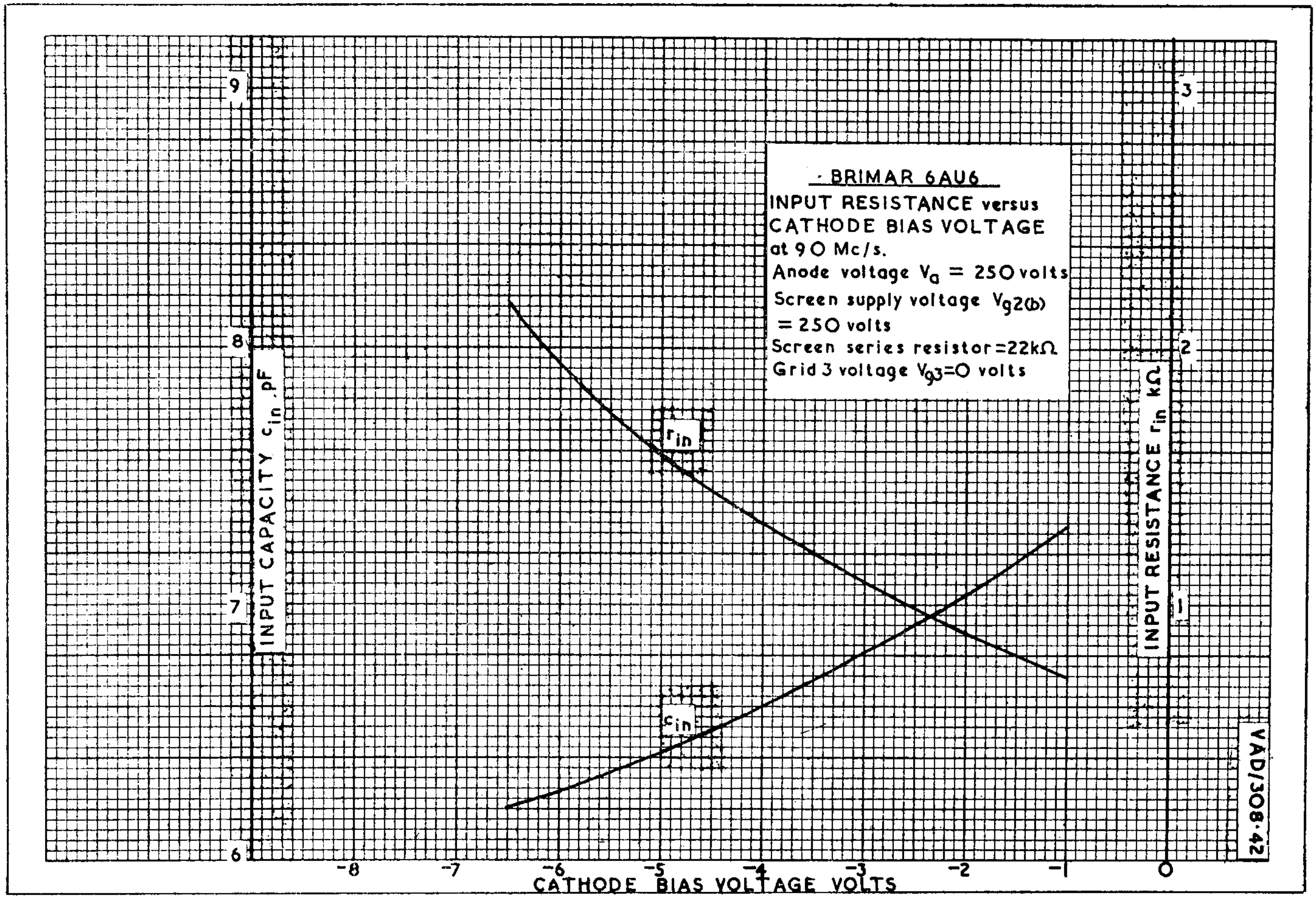

BRIMAR 6AU6
INPUT RESISTANCE & INPUT CAPACITY versus A.V.C. VOLTAGE at 50 Mc/s
Anode voltage $V_a = 250$ volts
Screen supply voltage $V_{g2(b)} = 250$ volts
Screen series resistor = 22 kΩ
Grid 3 voltage $V_{g3} = 0$ volts
INPUT CAPACITY c_{in}, pF
INPUT RESISTANCE r_{in} kΩ
r_{in}
c_{in}
A.V.C. VOLTAGE VOLTS
VAD/308·38



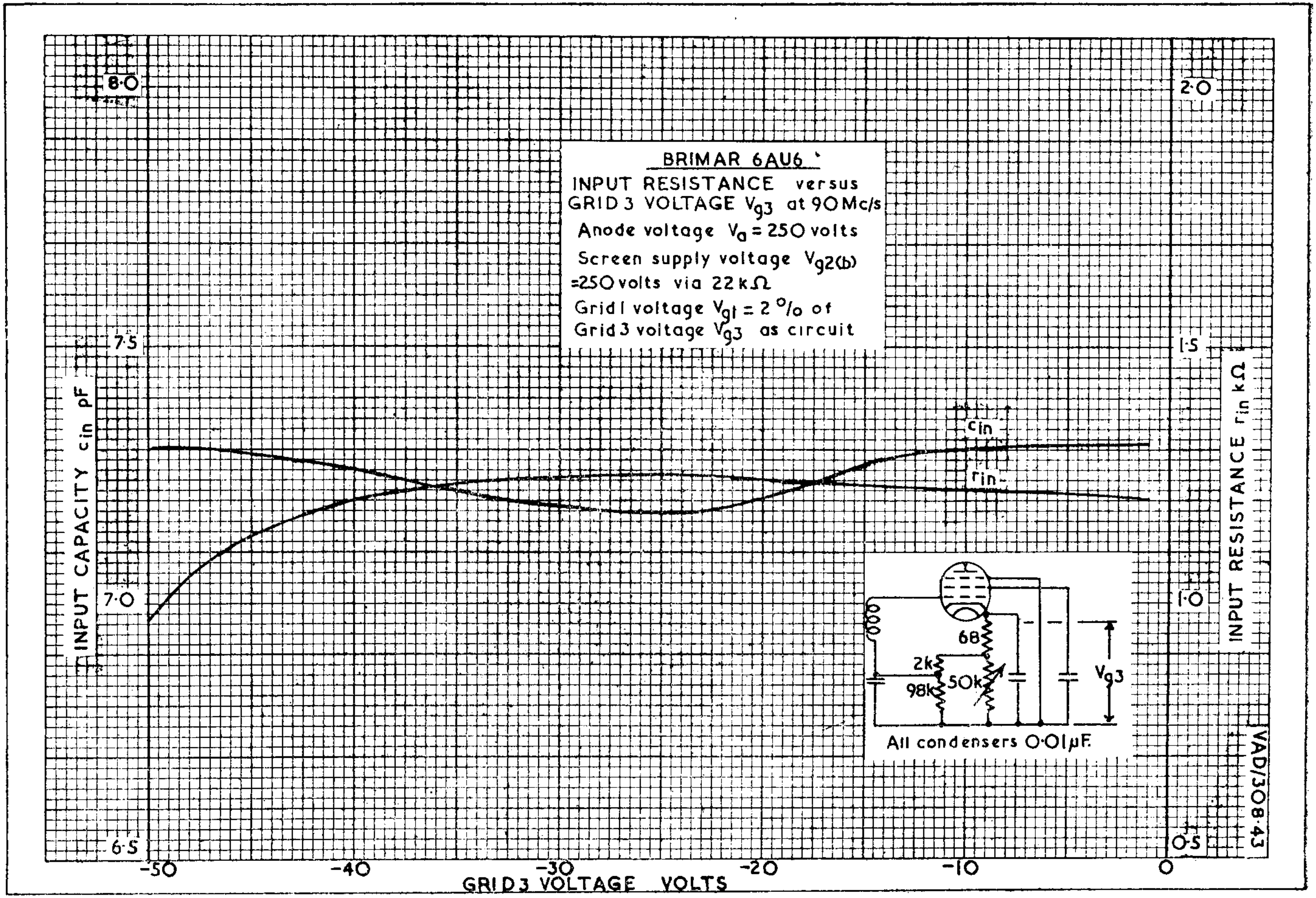
BRIMAR 6AU6
INPUT RESISTANCE versus
CATHODE BIAS VOLTAGE
at 50 Mc/s
Anode voltage V_a = 250 volts
Screen supply voltage $V_{g2(b)}$
= 250 volts
Screen series resistor = 22kΩ
Grid 3 voltage V_{g3} = 0 volts
INPUT CAPACITY c_{in} pF
INPUT RESISTANCE r_{in} kΩ
CATHODE BIAS VOLTAGE VOLTS
r_{in}
c_{in}
10
9
8
7
14
12
10
8
6
4
2
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
VAD/308·39


BRIMAR 6AU6
INPUT RESISTANCE versus
GRID 3 VOLTAGE V_{g3} at 50Mc/s
Anode voltage V_a = 250 volts
Screen supply voltage $V_{g2(b)}$
= 250 volts via 22kΩ
Grid 1 voltage V_{g1} = 2% of
Grid 3 voltage V_{g3} as circuit.
INPUT CAPACITY c_{in} pF
9·0
8·5
8·0
7·5
INPUT RESISTANCE r_{in} kΩ
6
5
4
3
c_{in}
r_{in}
68
2k
50k
98k
V_{g3}
All condensers 0·01μF
-50
-40
-30
-20
-10
0
GRID 3 VOLTAGE VOLTS
VAD/308·40

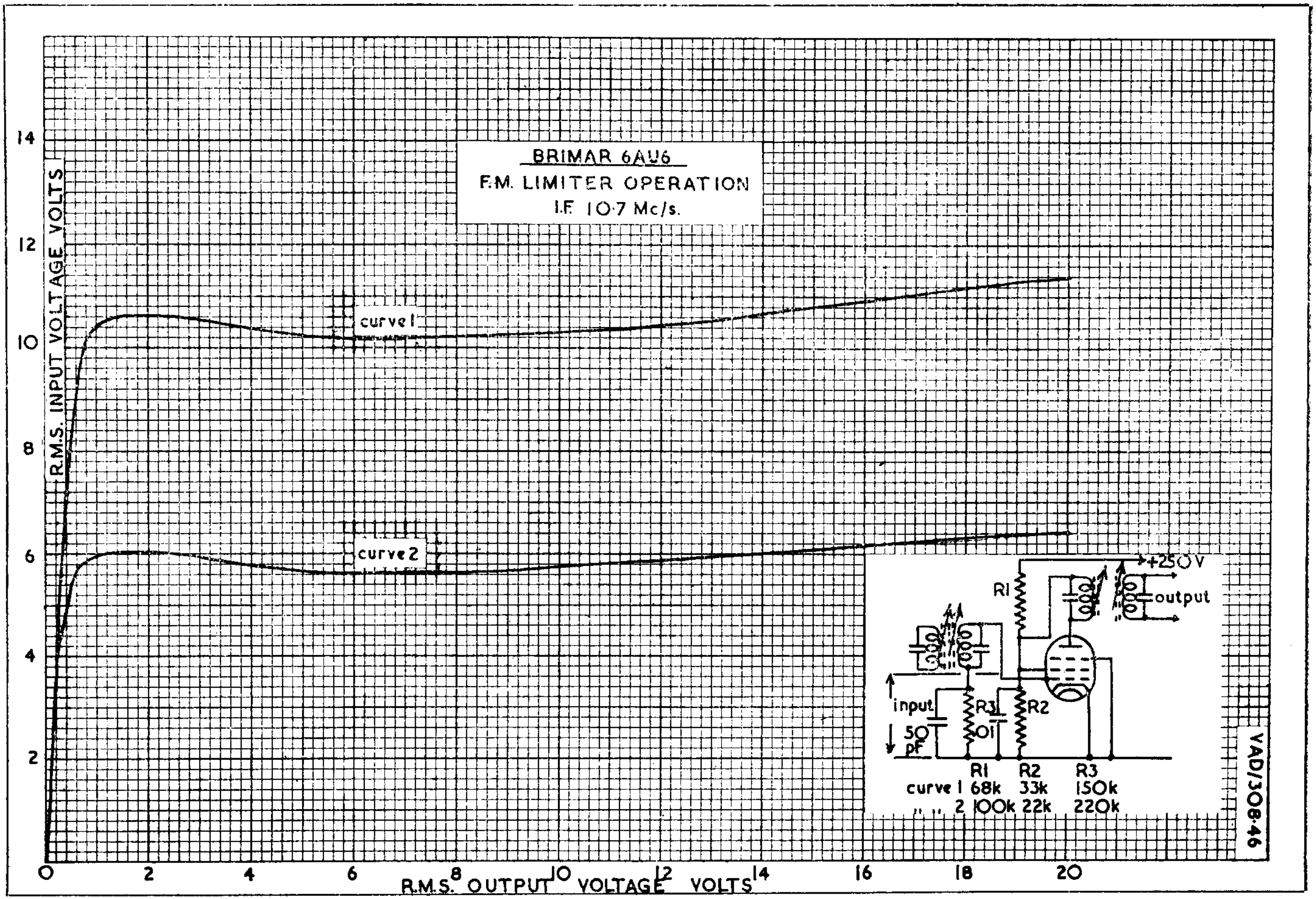

BRIMAR 6AU6
INPUT RESISTANCE versus A.V.C VOLTAGE
at 90Mc/s.
Anode voltage V_a = 250 volts
Screen supply voltage $V_{g2(b)}$ = 250 volts
Screen series resistor = 22kΩ
Grid 3 voltage V_{g3} = 0 volts
Cathode bias resistor = 68Ω
INPUT CAPACITY c_{in} pF
8
7
6
INPUT RESISTANCE r_{in} kΩ
6
5
4
3
2
1
c_{in}
r_{in}
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
A.V.C. VOLTAGE VOLTS
VAD/308·41



BRIMAR 6AU6
INPUT RESISTANCE versus
CATHODE BIAS VOLTAGE
at 90 Mc/s.
Anode voltage Va = 250 volts
Screen supply voltage Vg2(b)
= 250 volts
Screen series resistor = 22kΩ
Grid 3 voltage Vg3 = 0 volts
rin
cin
INPUT CAPACITY cin, pF
INPUT RESISTANCE rin kΩ
CATHODE BIAS VOLTAGE VOLTS
9
8
7
6
3
2
1
-8
-7
-6
-5
-4
-3
-2
-1
0
VAD/308·42



BRIMAR 6AU6
INPUT RESISTANCE versus GRID 3 VOLTAGE V_{g3} at 90 Mc/s
Anode voltage $V_a = 250$ volts
Screen supply voltage $V_{g2(b)}$ = 250 volts via 22 kΩ
Grid 1 voltage V_{g1} = 2 % of Grid 3 voltage V_{g3} as circuit
c_{in}
r_{in}
68
2k
98k
50k
V_{g3}
All condensers 0·01 μF.
INPUT CAPACITY c_{in} pF
INPUT RESISTANCE r_{in} kΩ
GRID 3 VOLTAGE VOLTS
8·0
7·5
7·0
6·5
2·0
1·5
1·0
0·5
-50
-40
-30
-20
-10
0
VAD/308·43



BRIMAR 6AU6
F.M. LIMITER OPERATION
I.F. 10·7 Mc/s.
curve 1
curve 2
R.M.S. INPUT VOLTAGE VOLTS
R.M.S. OUTPUT VOLTAGE VOLTS
0
2
4
6
8
10
12
14
16
18
20
+250V
output
input
50 pF
R1
R2
R3
·01
R1 R2 R3
curve 1 68k 33k 150k
" " 2 100k 22k 220k
VAD/308·46

BRIMAR

RECEIVING VALVE
6BA6

APPLICATION REPORT VAD/509.2

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

Issued March, 1950. Reprinted January, 1952.

INTRODUCTION: The Brimar 6BA6 is an indirectly-heated variable-mu RF pentode. The heater is intended for operation in parallel with other valves in AC operated equipment. The valve is designed for use as an RF or IF amplifier; suitable shielding and short leads provide a good performance in high frequency circuits. This report contains characteristics of the valve and details of its performance.

DESCRIPTION: The valve consists of a miniature variable-mu RF pentode having a mutual conductance of the order of 4 mA/V and is mounted in a standard T5½ bulb and fitted with a B7G standard base.

CHARACTERISTICS:	Indirectly-heated oxide-coated cathode.	
	Heater Voltage	6·3 volts
	Heater Current	0·3 amperes
	Max. DC Heater-Cathode Potential	250 volts
DIMENSIONS:	Max. Overall Length	2-1/8 ins.
	Max. Diameter	3/4 ins.
	Max. Seated Height (excluding tip)	1-19/32 ins.
BASE:	Type B7G	
BASE CONNECTIONS:	Pin 1 Control Grid	
	Pin 2 Suppressor and Internal Shield	
	Pin 3 Heater	
	Pin 4 Heater	
	Pin 5 Anode	
	Pin 6 Screen	
	Pin 7 Cathode	
MAXIMUM RATINGS:	Max. Anode Voltage	300 volts
	Max. Screen Voltage	125 volts
	Max. Screen Supply Voltage	300 volts
	Max. Anode Dissipation	3·0 watts
	Max. Screen Dissipation	0·6 watts
CAPACITIES (approx.):	Measured with no external shield.	
	Pentode Connected:	
	Input	5·5 pF
	Output	5·0 pF
	Grid-Anode	0·0035 pF max.
	Grounded Grid Operation:	
	Anode-Cathode	0·01 pF
	Input	6·0 pF
	Output	5·6 pF

CHARACTERISTIC CURVES: Attached to this report are curves showing:

a. Anode current (i_a) plotted against control grid voltage for various screen voltages (Curve No. 309·28).

b. Mutual conductance (g_m) and anode impedance (r_a) against control grid voltage for fixed and sliding screen voltage operation (Curve No. 309·29).

c. Anode current plotted against anode voltage for a screen voltage of 125 volts (Curve No. 309·30) and for a screen voltage of 100 volts (Curve No. 309·31).

TYPICAL OPERATING CONDITIONS

Class A Amplifier (suppressor connected to cathode):

Heater Voltage	6·3	6·3	6·3	volts
Anode Voltage	100	250	250	volts
Screen Supply Voltage	—	—	250	volts
Series Screen Resistor	—	—	33000	ohms
Screen Voltage	100	100	—	volts
Grid Voltage	—1	—1	—1	volts
Cathode Bias Resistor	68	68	68	ohms
Anode Current	10·8	11	11	mA
Screen Current	4·4	4·2	4·2	mA
Anode Impedance	0·25	1·5	1·5	megohms
Inner Amplification Factor	22·7	21·0	21·3	
Grid Voltage for g_m = 1/100 of its value at grid voltage of —1 volt	—21	—21	—51	volts
Suppressor Voltage for g_m = 1/100 of its value at grid voltage of —1 volt and suppressor voltage of zero	—37·5	—73	—70	volts
Equivalent Noise Resistance	3800	3650	3650	ohms
Input Impedance at 45 Mc/s	4500	4500	4500	ohms
Input Impedance at 90 Mc/s	900	900	900	ohms

Operation as an RF or IF Amplifier: The valve is intended primarily for service in the above application. It is recommended that cathode bias always be used rather than fixed bias and that normally the suppressor grid and the internal shield be connected to the cathode at the socket. The valve socket should be so mounted that the grid and anode leads to the remainder of the circuit run in opposite directions to each other and are as short as is practicable in order to ensure high gain with stability. The decoupling components should also be chosen and located with care for similar reasons.

When used in VHF receivers the valve may be employed with normal pentode connections or as a grounded grid amplifier at frequencies of the order of 100 Mc/s. It is also very efficient as an IF amplifier using intermediate frequencies around 10 Mc/s. When so employed a stage gain of 44 times can be expected with a total bandwidth of 200 Kc/s for 3 db down with IF coils of Q 70 and tuning capacity 50 pF.

For those applications where very high frequencies are employed and changes in input capacity and input impedance are undesirable, it is advisable that grid bias be applied to the control grid and suppressor grid simultaneously, the control grid being biased to a value of approximately 2·5% of that applied to the suppressor grid.

Curves are attached to this report showing input capacity and input impedance plotted against control grid voltage for the sliding screen conditions at 50 Mc/s (Curve No. 309·35), and similarly but for auto bias (Curve No. 309·36). Curves Nos. 309·37 and 309·38 are similar to the above but taken at a frequency of 90 Mc/s.

Operation as a Resistance-Capacity Coupled Amplifier: Although the valve has a variable-mu control grid characteristic it may still be used for small inputs as an RC coupled amplifier; curves are attached to this report covering this application. Curve No. 309·32 is plotted with an anode load resistor of 100,000 ohms and shows the relationship between anode current, screen current and control grid voltage for various screen voltages. Curves Nos. 309·33 and 309·34 are similar to the above but plotted for anode load resistors of 220,000 and 470,000 ohms respectively. The method of using these curves to design an RC coupled amplifier is described below.

If, for example, it is desired to use the valve at a supply voltage of 250 volts with an anode load resistor of 220,000 ohms and a succeeding valve grid leak of 470,000 ohms, then an examination of Curve No. 309·33 shows that grid current (I_{g1}) commences at about —0·7 volts, hence a grid bias should be chosen such that the signal never swings the grid to a value of much less than —1 volt. If a value of —1·5 volts is taken then fairly straight portions of the I_a/V_a curves are available for V_{g2} 30 volts. Taking the operating point as V_{g2} 30 volts and V_{g1} —1·5 volts, the plate current will be 0·81 mA and the screen current I_{g2} 0·28 mA, hence the cathode resistor will be:

$$\frac{1{\cdot}5 \times 1000}{0{\cdot}81 + 0{\cdot}28} \text{ or } 1380 \text{ ohms;}$$

in practice 1500 ohms would be used. The screen dropping resistor would be:

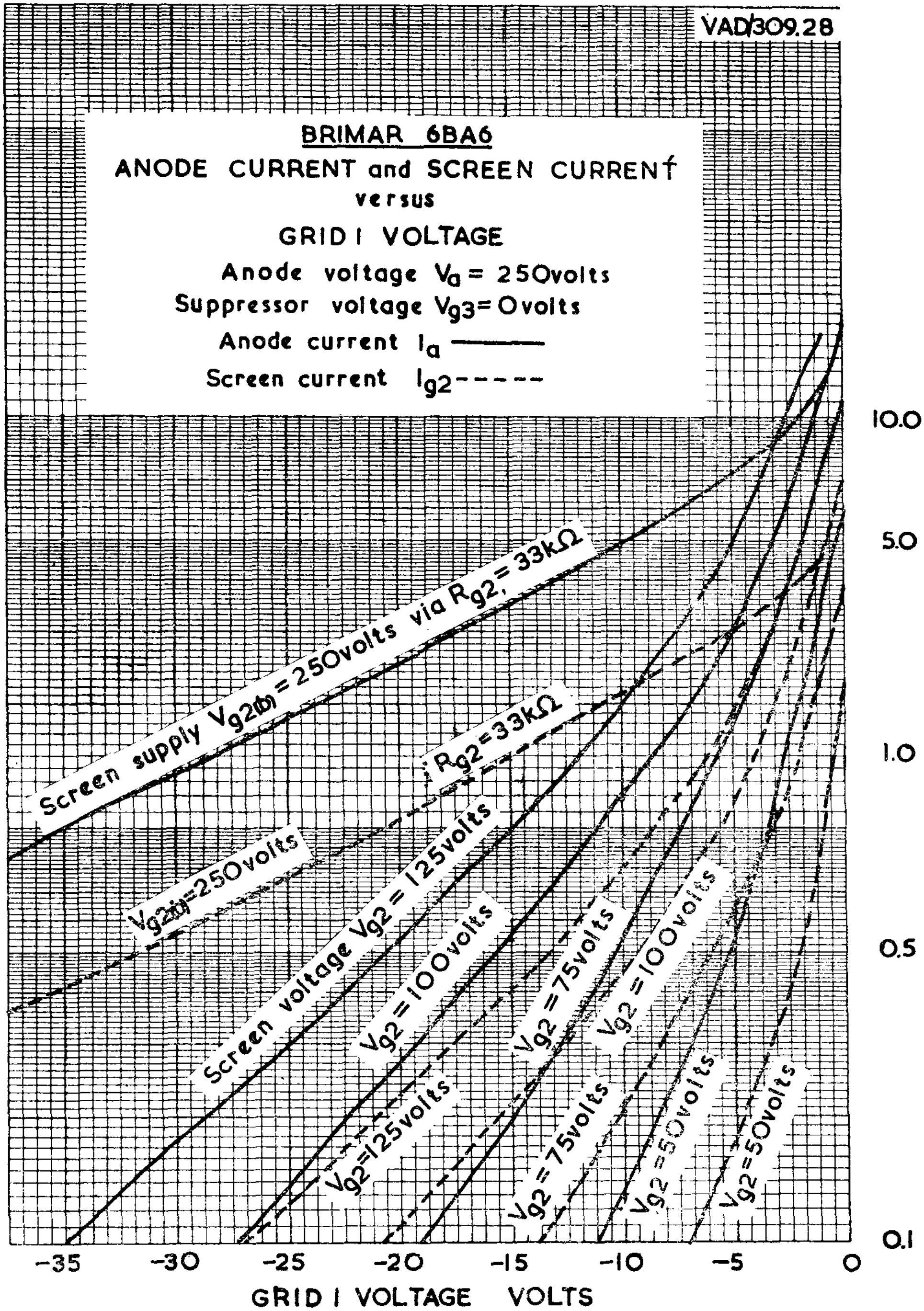
$$\frac{250 - 30}{0{\cdot}28} \times 1000, \text{ or } 785{,}000 \text{ ohms.}$$

Again the nearest preferred value would be 680,000 ohms. If the grid has a peak AF input of ±0·5 volts as a maximum, the anode current will vary from 0·60 mA at a grid voltage of —2·0 volts to 1·07 mA at —1 volt, hence a change of 0·47 mA in 220,000 is 104 volts peak-peak. This is an output of 52 volts peak and a voltage gain of 104.

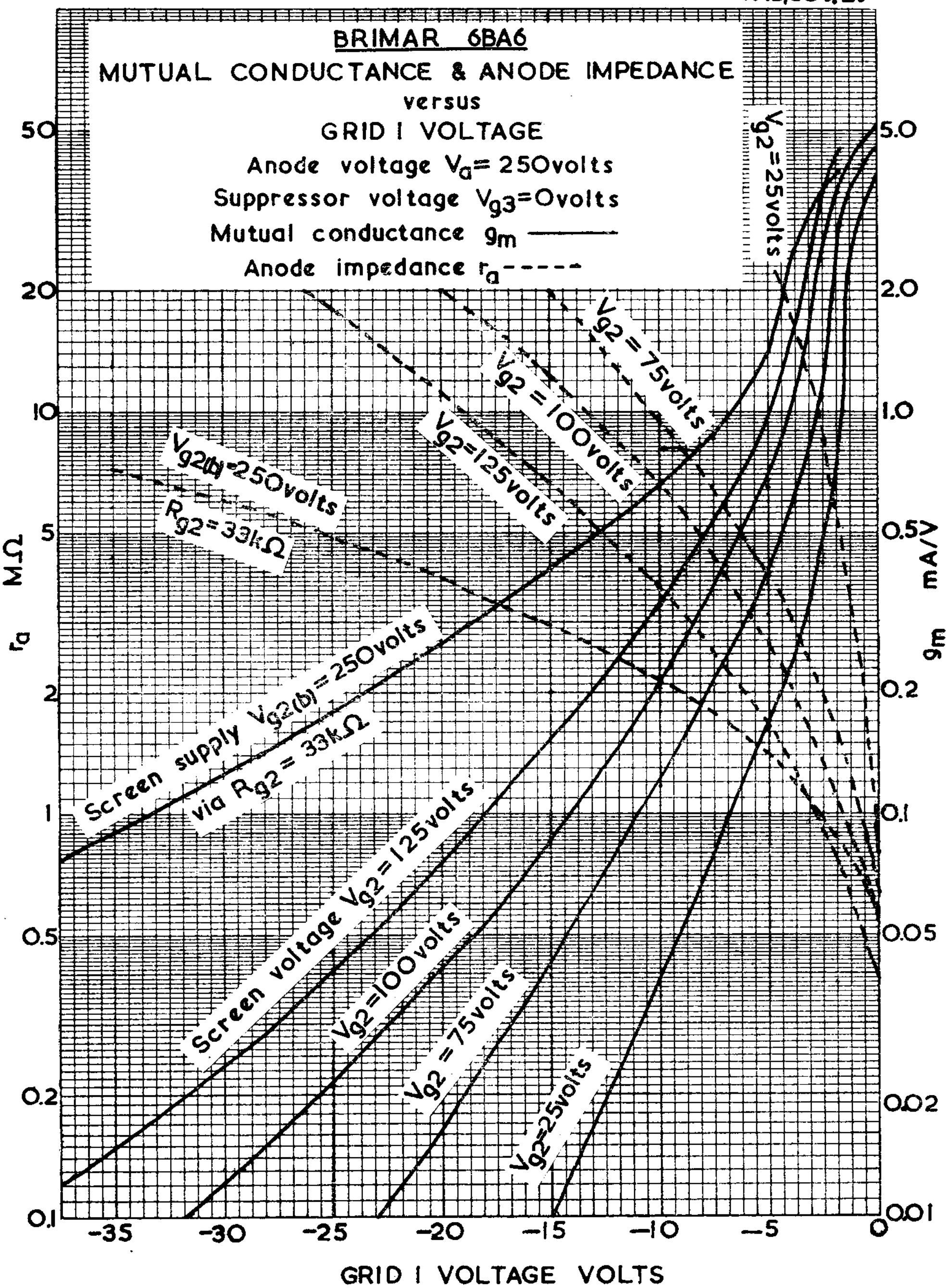
As allowance must be made for the succeeding valve grid leak the above values will be reduced by a factor of:

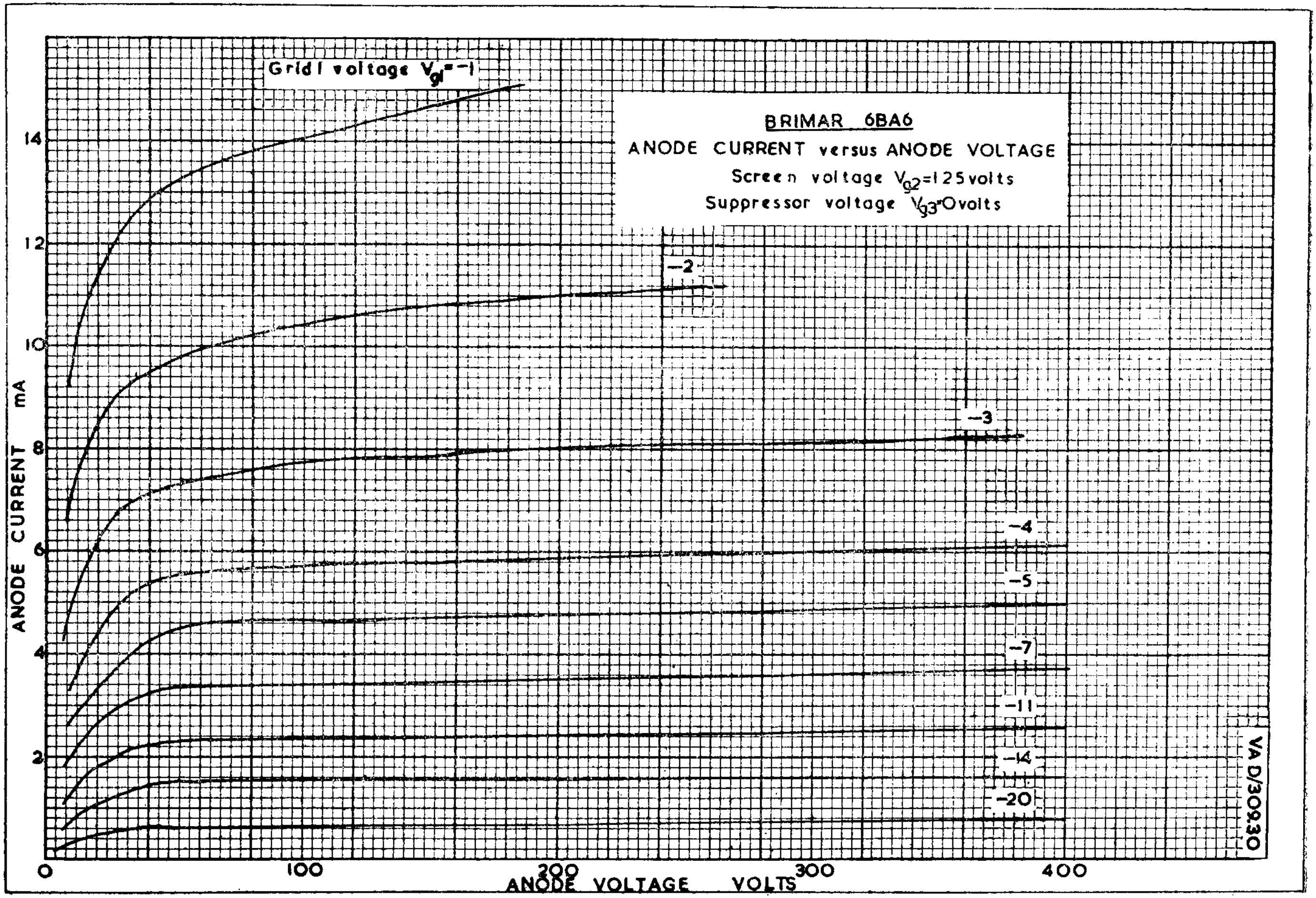
$$\frac{470{,}000}{470{,}000 + 220{,}000} \text{ or } 0{\cdot}68,$$

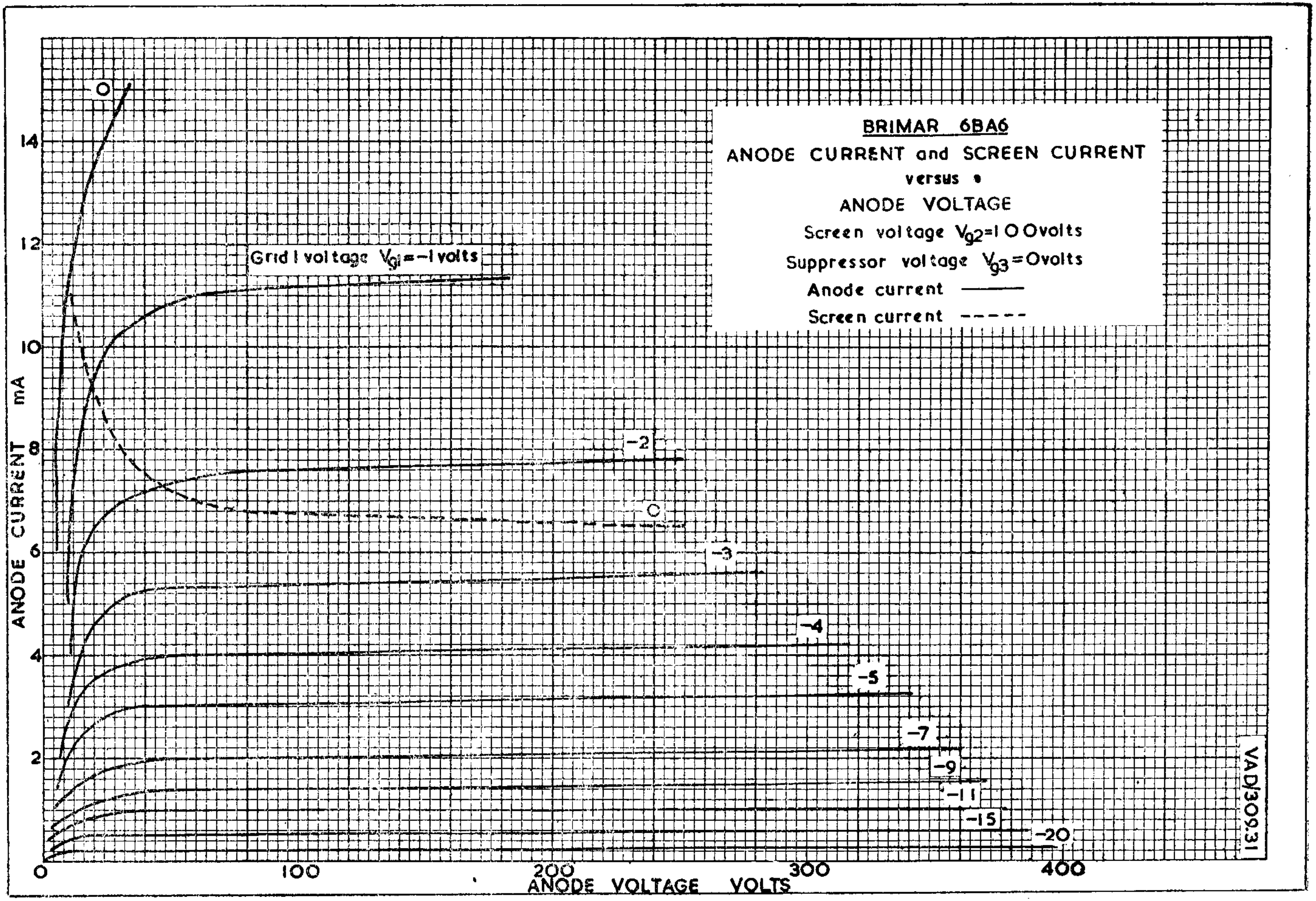
hence the actual operating gain will be 70 and the output voltage 50 volts peak for an input of 0·7 volts peak. An estimate of the distortion can be obtained by calculating in a similar manner the voltage gain for the positive swing (—1·5 to —1·0 volts) and the negative swing (—1·5 to —2·0 volts) separately, the resultant figures indicating the amount by which one peak is amplified more than the other.

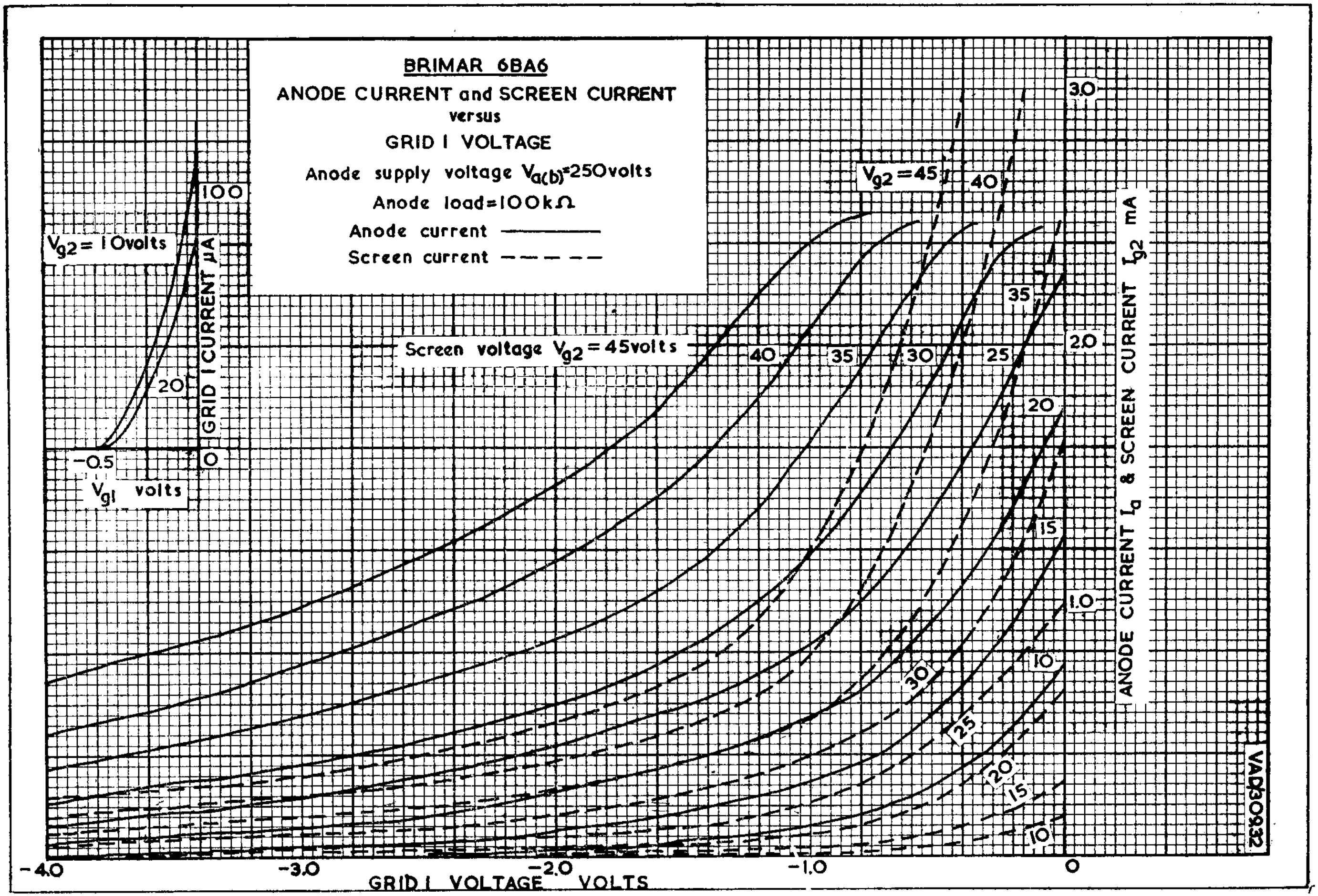

VAD/309.28
BRIMAR 6BA6
ANODE CURRENT and SCREEN CURRENT
versus
GRID I VOLTAGE
Anode voltage V_a = 250volts
Suppressor voltage V_{g3}= 0volts
Anode current I_a ———
Screen current I_{g2}-----
Screen supply $V_{g2(b)}$ = 250volts via R_{g2} = 33kΩ
R_{g2}=33kΩ
$V_{g2(b)}$=250volts
Screen voltage V_{g2} = 125volts
V_{g2} = 100volts
V_{g2} = 75volts
V_{g2} = 100volts
V_{g2}=125volts
V_{g2} = 75volts
V_{g2} =50volts
V_{g2} =50volts
10.0
5.0
1.0
0.5
0.1
ANODE & SCREEN CURRENT mA
−35
−30
−25
−20
−15
−10
−5
0
GRID I VOLTAGE VOLTS

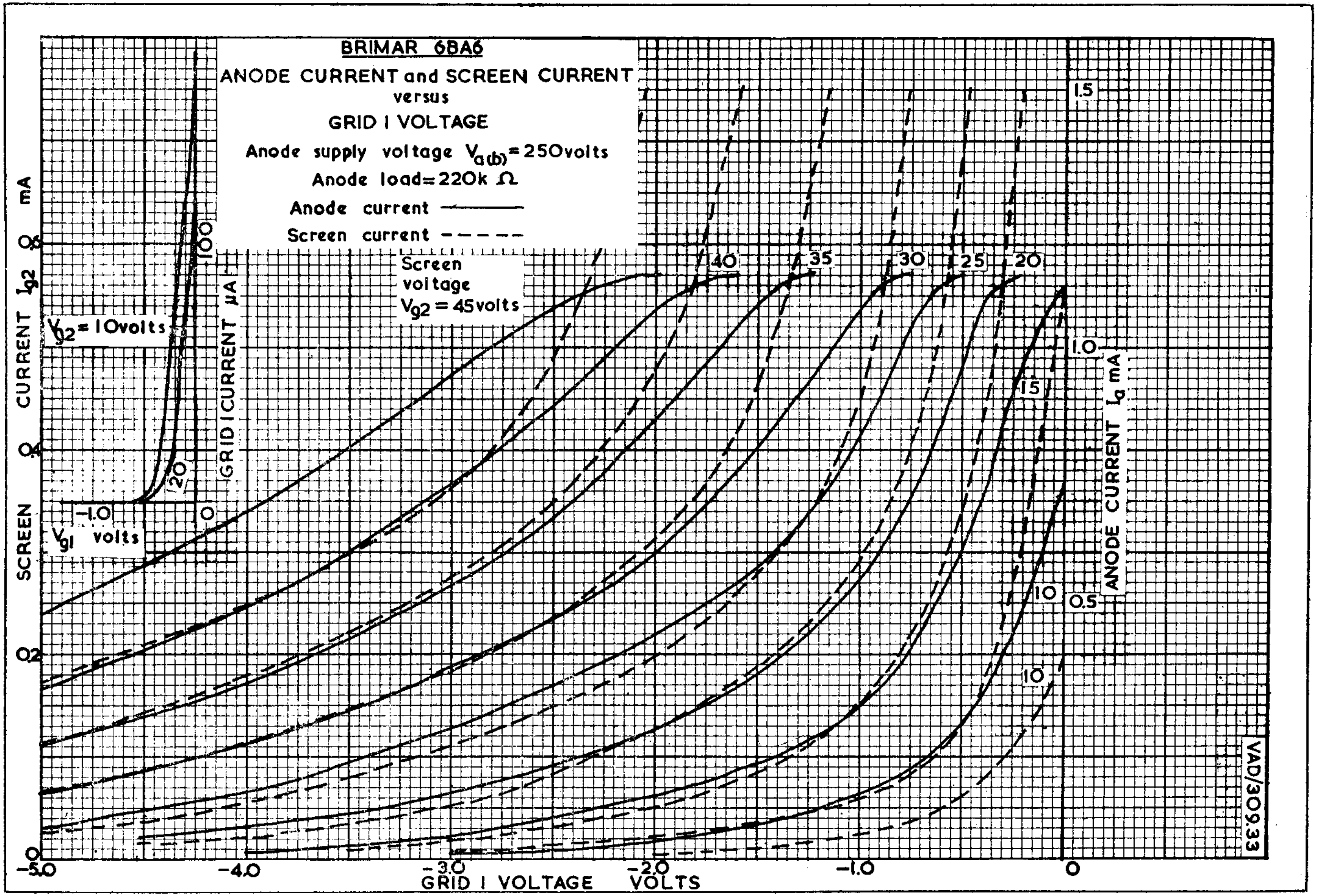
VAD/309.29

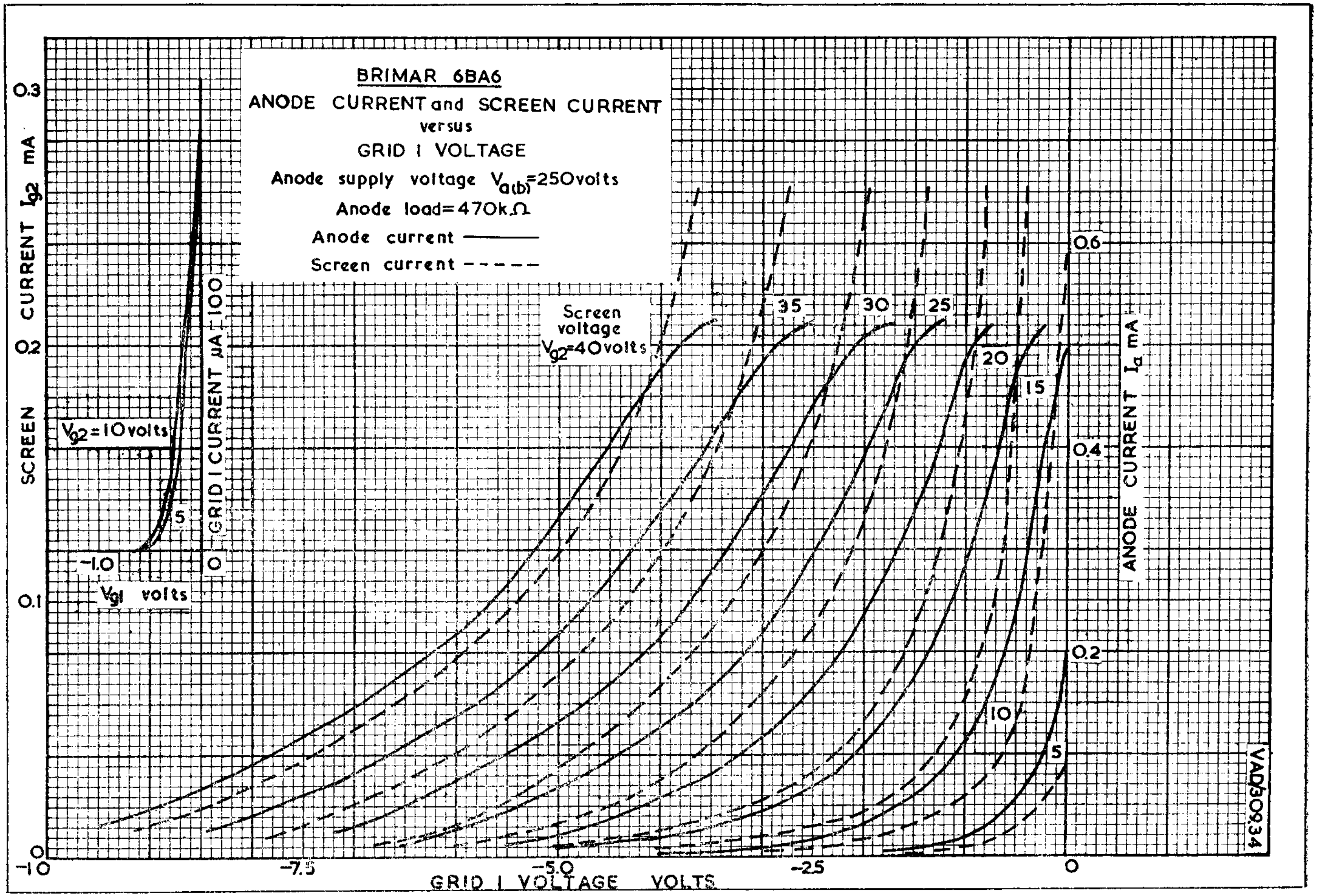

BRIMAR 6BA6
MUTUAL CONDUCTANCE & ANODE IMPEDANCE
versus
GRID I VOLTAGE
Anode voltage V_a = 250 volts
Suppressor voltage V_{g3} = 0 volts
Mutual conductance g_m ———
Anode impedance r_a - - - - -
V_{g2} = 25 volts
V_{g2} = 75 volts
V_{g2} = 100 volts
V_{g2} = 125 volts
$V_{g2(b)}$ = 250 volts
R_{g2} = 33kΩ
Screen supply $V_{g2(b)}$ = 250 volts
via R_{g2} = 33kΩ
Screen voltage V_{g2} = 125 volts
V_{g2} = 100 volts
V_{g2} = 75 volts
V_{g2} = 25 volts
r_a MΩ
50
20
10
5
2
1
0.5
0.2
0.1
g_m mA/V
5.0
2.0
1.0
0.5
0.2
0.1
0.05
0.02
0.01
−35
−30
−25
−20
−15
−10
−5
0
GRID I VOLTAGE VOLTS

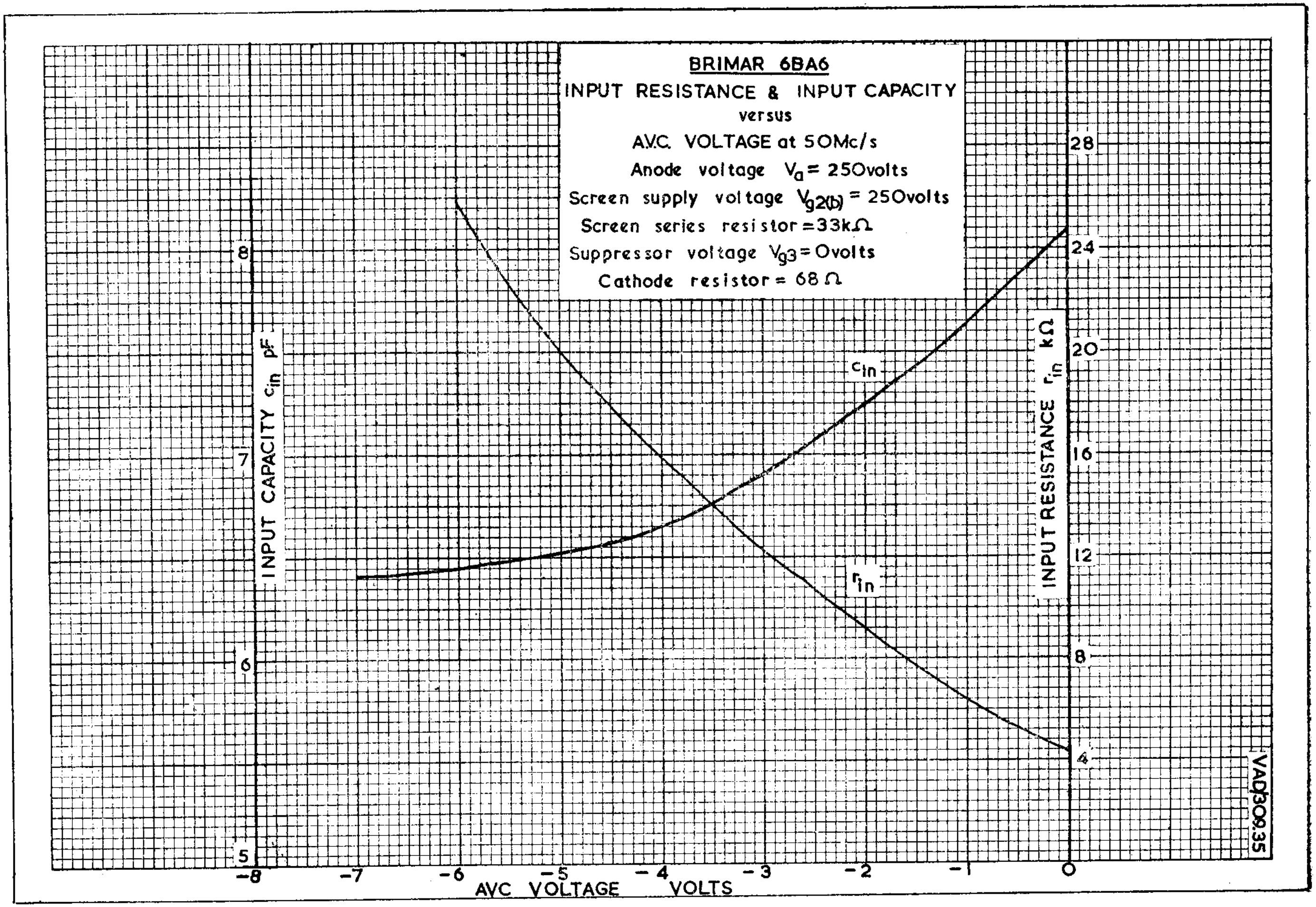

BRIMAR 6BA6
ANODE CURRENT versus ANODE VOLTAGE
Screen voltage V_{g2}=125 volts
Suppressor voltage V_{g3}=0 volts
Grid1 voltage V_{g1}=−1
−2
−3
−4
−5
−7
−11
−14
−20
ANODE CURRENT mA
14
12
10
8
6
4
2
0
100
200
300
400
ANODE VOLTAGE VOLTS
VA D/309.30

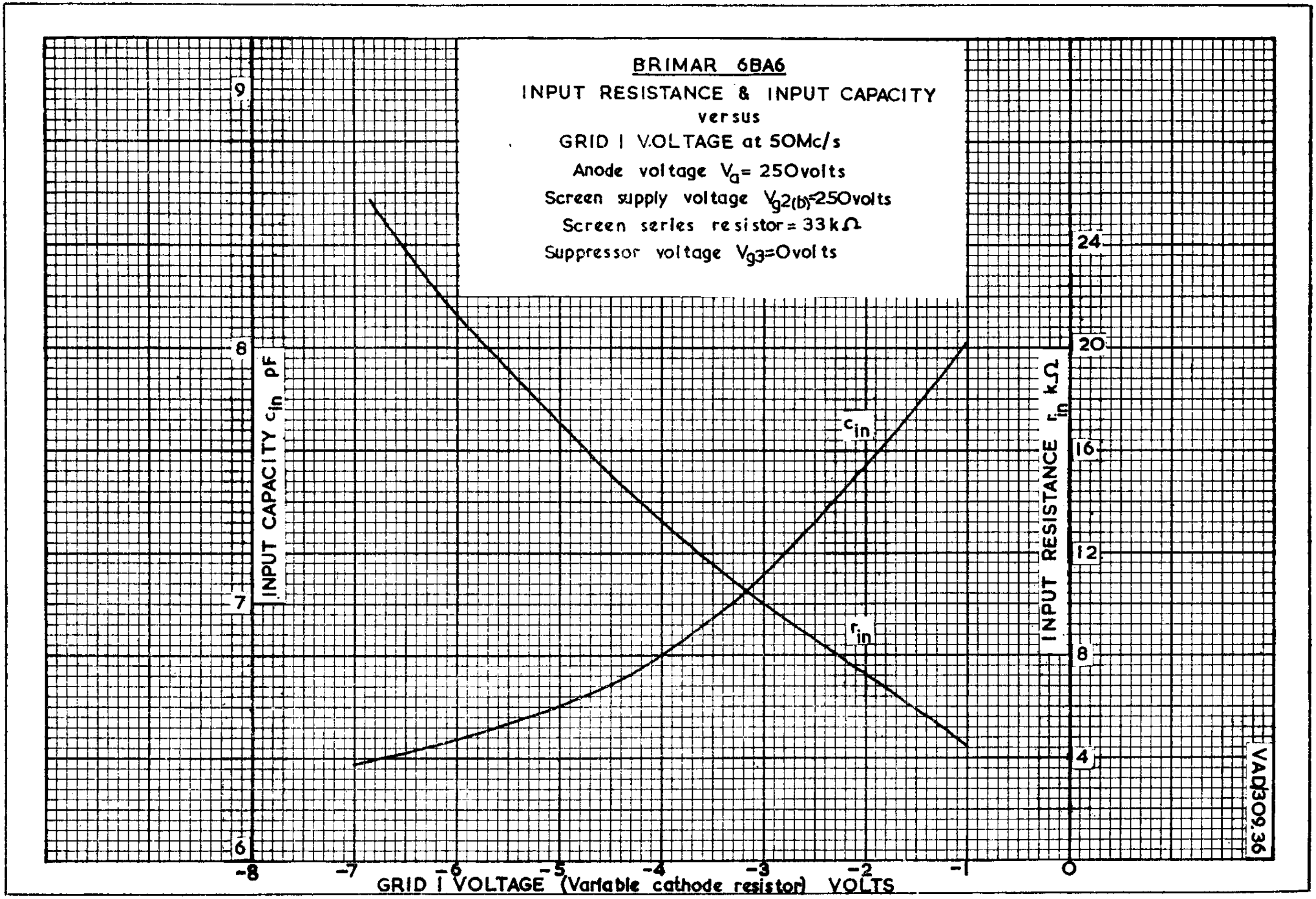

BRIMAR 6BA6
ANODE CURRENT and SCREEN CURRENT
versus
ANODE VOLTAGE
Screen voltage V_{g2}=100 volts
Suppressor voltage V_{g3}=0 volts
Anode current ———
Screen current - - - - -
Grid I voltage V_{g1}=−1 volts
0
−2
0
−3
−4
−5
−7
−9
−11
−15
−20
ANODE CURRENT mA
ANODE VOLTAGE VOLTS
0
100
200
300
400
2
4
6
8
10
12
14
VAD/309.31

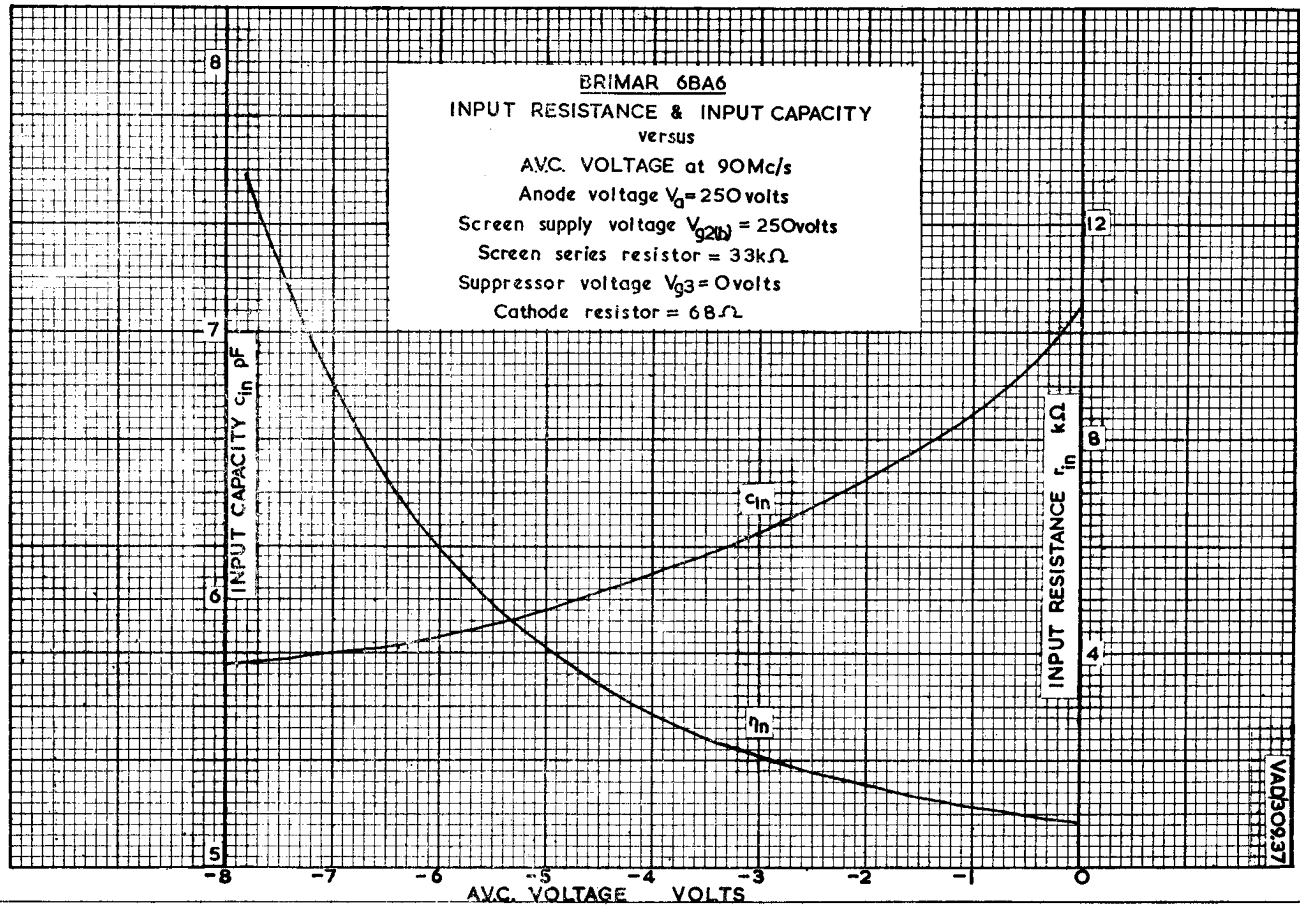

BRIMAR 6BA6
ANODE CURRENT and SCREEN CURRENT
versus
GRID I VOLTAGE
Anode supply voltage $V_{a(b)}$=250volts
Anode load=100kΩ
Anode current ————
Screen current — — — —
Screen voltage V_{g2}=45volts
V_{g2}=45
V_{g2}=10volts
GRID I CURRENT μA
V_{g1} volts
ANODE CURRENT I_a & SCREEN CURRENT I_{g2} mA
GRID I VOLTAGE VOLTS
-4.0
-3.0
-2.0
-1.0
0
-0.5
100
20
0
3.0
2.0
1.0
40
35
30
25
20
15
10
VAD/30932

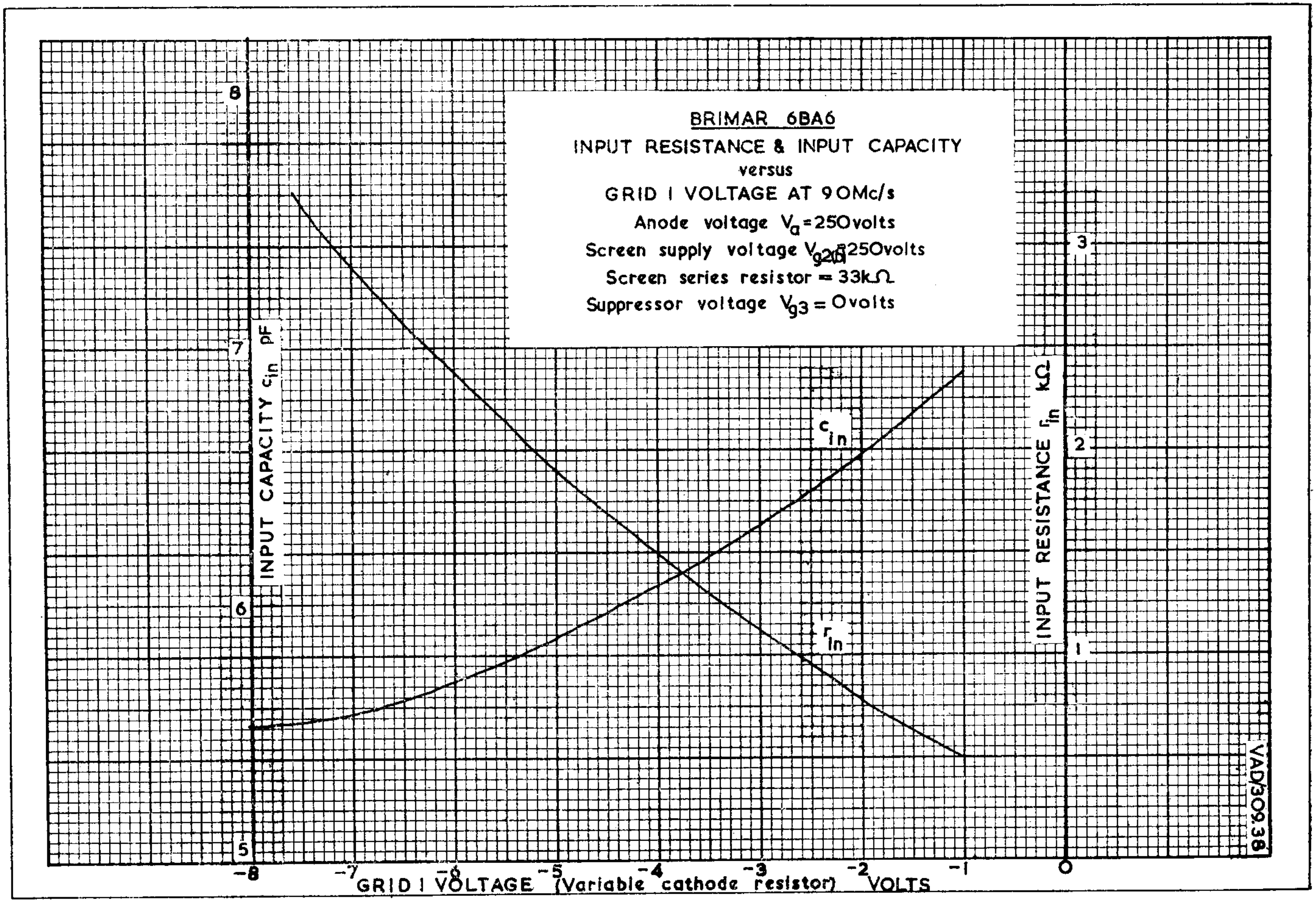

BRIMAR 6BA6
ANODE CURRENT and SCREEN CURRENT
versus
GRID I VOLTAGE
Anode supply voltage $V_{a(b)}$ = 250 volts
Anode load = 220k Ω
Anode current
Screen current
Screen voltage
V_{g2} = 45 volts
V_{g2} = 10 volts
V_{g1} volts
GRID I CURRENT μA
SCREEN CURRENT I_{g2} mA
ANODE CURRENT I_a mA
GRID I VOLTAGE VOLTS
VAD/309.33


BRIMAR 6BA6
ANODE CURRENT and SCREEN CURRENT
versus
GRID I VOLTAGE
Anode supply voltage $V_{a(b)}$=250volts
Anode load=470kΩ
Anode current ———
Screen current - - - - -
Screen voltage V_{g2}=40volts
35
30
25
20
15
10
5
V_{g2}=10volts
-1.0
V_{g1} volts
GRID I CURRENT µA
0
100
SCREEN CURRENT I_{g2} mA
0.3
0.2
0.1
0
ANODE CURRENT I_a mA
0.6
0.4
0.2
GRID I VOLTAGE VOLTS
-10
-7.5
-5.0
-2.5
0
VAD/30934


BRIMAR 6BA6
INPUT RESISTANCE & INPUT CAPACITY
versus
A.V.C. VOLTAGE at 50Mc/s
Anode voltage V_a = 250volts
Screen supply voltage $V_{g2(b)}$ = 250volts
Screen series resistor = 33kΩ
Suppressor voltage V_{g3} = 0volts
Cathode resistor = 68 Ω
INPUT CAPACITY c_{in} pF
INPUT RESISTANCE r_{in} kΩ
c_{in}
r_{in}
8
7
6
5
28
24
20
16
12
8
4
−8
−7
−6
−5
−4
−3
−2
−1
0
AVC VOLTAGE VOLTS
VAD/309.35


BRIMAR 6BA6
INPUT RESISTANCE & INPUT CAPACITY
versus
GRID I VOLTAGE at 50Mc/s
Anode voltage V_a= 250volts
Screen supply voltage $V_{g2(b)}$=250volts
Screen series resistor = 33kΩ
Suppressor voltage V_{g3}=0volts
INPUT CAPACITY c_{in} pF
INPUT RESISTANCE r_{in} kΩ
c_{in}
r_{in}
9
8
7
6
24
20
16
12
8
4
-8
-7
-6
-5
-4
-3
-2
-1
0
GRID I VOLTAGE (Variable cathode resistor) VOLTS
VAD/309.36


BRIMAR 6BA6
INPUT RESISTANCE & INPUT CAPACITY
versus
A.V.C. VOLTAGE at 90Mc/s
Anode voltage V_a = 250 volts
Screen supply voltage $V_{g2(b)}$ = 250volts
Screen series resistor = 33kΩ
Suppressor voltage V_{g3} = 0volts
Cathode resistor = 68Ω
INPUT CAPACITY c_{in} pF
INPUT RESISTANCE r_{in} kΩ
c_{in}
r_{in}
A.V.C. VOLTAGE VOLTS
8
7
6
5
12
8
4
-8
-7
-6
-5
-4
-3
-2
-1
0
VAD/309.37


BRIMAR 6BA6
INPUT RESISTANCE & INPUT CAPACITY
versus
GRID I VOLTAGE AT 90Mc/s
Anode voltage V_a = 250 volts
Screen supply voltage $V_{g2(b)}$ = 250 volts
Screen series resistor = 33kΩ
Suppressor voltage V_{g3} = 0 volts
INPUT CAPACITY c_{in} pF
INPUT RESISTANCE r_{in} kΩ
c_{in}
r_{in}
8
7
6
5
3
2
1
−8
−7
−6
−5
−4
−3
−2
−1
0
GRID I VOLTAGE (Variable cathode resistor) VOLTS
VAD/309.38

BRIMAR

RECEIVING VALVE

6BE6

APPLICATION REPORT VAD/515.1

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

Issued March, 1950. Reprinted January, 1952.

INTRODUCTION: The Brimar 6BE6 is a miniature indirectly-heated pentagrid frequency changer intended for use in all wave receivers. The features are a high conversion gain together with high anode impedance and a low frequency drift.

The heater is intended for operation in parallel with other valves in AC operated equipment. This report contains characteristics of the valve and details of its use as a frequency changer in superheterodyne receivers.

DESCRIPTION: The valve is a pentagrid having a single electron stream but with an oscillator or injector grid and a control or signal grid. The valve may be used with a separate oscillator or in a self-oscillator circuit up to frequencies of the order of 100 Mc/s. The structure is mounted in a standard T5½ bulb and is based with a BVA standard base type B7G.

CHARACTERISTICS:	Indirectly-heated oxide-coated cathode.	
	Heater Voltage	6·3 volts
	Heater Current	0·3 amperes
	Max. DC Heater-Cathode potential	250 volts
	Max. Total Cathode Current	14 mA
DIMENSIONS:	Max. Overall Length	2-1/8 ins.
	Max. Diameter	3/4 ins.
	Max. Seated Height (excluding tip)	1-19/32 ins.
BASE:	Type B7G	
BASE CONNECTIONS:	Pin 1 Oscillator Grid (grid 1)	
	Pin 2 Cathode and Suppressor (grid 5)	
	Pin 3 Heater	
	Pin 4 Heater	
	Pin 5 Anode	
	Pin 6 Screen Grids (grids 2 and 4)	
	Pin 7 Control Grid (grid 3)	
MAXIMUM RATINGS:	Max. Anode Voltage	300 volts
	Max. Screen Voltage	100 volts
	Max. Screen Supply Voltage	300 volts
	Max. Anode Dissipation	1·0 watts
	Max. Screen Dissipation	1·0 watts
CAPACITIES (approx.):	Measured with no external shield.	
	RF Input	7·2 pF
	IF Output	8·5 pF
	Oscillator Input (Grid 1-All)	5·5 pF
	Oscillator Grid-Cathode	2·8 pF
	Cathode to all less Grid 1	15 pF
	Oscillator Grid-Anode	0·05 pF (max.)
	Control Grid-Anode	0·3 pF (max.)
	Control Grid-Oscillator Grid	0·15 pF (max.)

CHARACTERISTIC CURVES: To this report are attached curves showing:

a. Conversion conductance (g_c) and conversion impedance (r_c) plotted against control grid voltage for various screen voltages under conditions of a separate oscillator (Curve No. 315·4) or a self-excited oscillator (Curve No. 315·5).

b. Conversion conductance (g_c), conversion impedance (r_c) and total cathode current (I_k) plotted against oscillator grid current for various screen voltages when used with a separate oscillator (Curve No. 315·6).

c. Conversion conductance (g_c) plotted against oscillator grid current for various positions of the cathode tap when used as a self-excited oscillator (Curve No. 315·7).

TYPICAL OPERATING CONDITIONS

Operation as a Frequency Changer with Separate Oscillator:

Heater Voltage	6·3	6·3	volts
Anode Voltage	100	250	volts
Screen Voltage	100	100	volts
Control Grid Voltage	—1·5	—1·5	volts
Oscillator Grid Resistor	20,000	20,000	ohms
Oscillator Grid Current	0·5	0·5	mA
Anode Current	2·8	3·0	mA
Screen Current	7·3	7·1	mA
Cathode Current	10·6	10·6	mA
Conversion Conductance	0·455	0·475	mA/V
Conversion Impedance	0·5	1·0	megohms
Control Grid Voltage when conversion conductance = 1/100 its value at control grid voltage of —1·5 volts	—30	—30	volts
Equivalent Noise Resistance	200,000	190,000	ohms
Input Impedance at 18 Mc/s	——	100,000	ohms

Operation as a Frequency Changer with Self-Excited Oscillator:

The operating conditions are the same as given above except that the control grid voltage is zero. When the valve is employed as an electron coupled oscillator the characteristics measured from the oscillator grid to anode and screen are as below:

Anode and Screen Voltage	100	volts
Control Grid, Oscillator Grid and Cathode Voltage	0	volts
Cathode Current	25	mA
Amplification Factor	20	
Mutual Conductance	7·5	mA/V

GENERAL RECOMMENDATIONS

1. HETERODYNE VOLTAGE:

a. Separate External Oscillator: Reference to Curve No. 315·6 shows that an oscillator grid (grid 1) current of 0·5 mA in the recommended value of the grid resistor of 20,000 ohms gives approximately optimum performance. A greater grid drive will provide slightly more conversion conductance but increases the total cathode current. The grid current should not be allowed to fall below about 0·2 mA on any waveband or under conditions of low mains voltage.

A minimum bias of —2 volts should be maintained on the control grid (grid 3), as this gives the maximum gain. On the higher frequencies a small neutralising condenser between the control grid and the oscillator grid may be found advantageous in a similar way to that found with other frequency changers of the heptode type.

Any suitable low μ triode such as the type 6C4 will provide adequate heterodyne voltage; a typical circuit (Ref. 315·53) shows the essential details.

b. Self-excited Oscillator: As the valve does not employ a separate oscillator anode, and since the screen (grid 2) is employed to reduce reaction between the control grid (grid 3) and oscillator grid (grid 1) thereby minimising frequency "pulling" with A.V.C. and re-radiation, it is essential that the screen be maintained at earth potential to signal and oscillator frequency voltages. The oscillation must be produced between the oscillator grid (grid 1) and cathode.

This does not involve difficulty due to the application of A.V.C. to the control grid (grid 3) because the total cathode current is little affected by bias on grid 3, since the electrons repelled towards the cathode by the negative field are intercepted by the side rods and metal "collectors" comprising grid 2, so that a decrease in current to the plate and grid 4 is compensated by an increase in current to grid 2. Further, due to the screening effect of grid 2 there is little feedback at signal and intermediate frequencies due to the cathode impedance.

A typical circuit (Ref. 315·7) shows the recommended arrangement. It will be seen that the cathode is tapped up the oscillator grid coil to provide regeneration in a conventional manner. Because a portion of the coil exists between cathode and earth it is essential that the voltage across this portion bears some relationship to that applied to the control grid, which will receive an equal and opposite voltage. As the voltage on grid 3 must be kept small, the cathode tap should be as low down the coil as possible consistent with satisfactory oscillation. The dotted curves (Ref. 315·7) show the relation between conversion conductance and the tap position, defined in terms of the percentage voltage between the tap and earth to that between the top end connected to grid 1 and earth.

It will be seen that an increase in this percentage decreases the conversion conductance in a marked manner, hence improper positioning of the cathode tap will result in poor performance. The design of a coil (in which there is considerable leakage inductance between ends of the coil) which effectively changes the position of the tap will result in poor performance particularly at the extremes of a waveband.

The percentage feedback can be measured most conveniently by means of a conventional valve voltmeter. The full line curves (Ref. 315·7) also show the relationship between the conversion conductance and oscillator grid current for various values of cathode-earth voltage. The full line curves assume that grid 1 is driven by a variable RF voltage to give various values of grid current, whilst the voltage between the cathode and earth is maintained constant by variation of the impedance between cathode and earth. In a similar manner the dotted curves assume a constant tap position but a variable total voltage corresponding to a variation in "Q" of the circuit.

No external bias need be used for the control grid when the valve is self-excited, although some small value will be provided by the A.V.C. circuit, if used. The measure of control of the anode current by either grid 1 or grid 3 is approximately the same; hence if during the negative voltage swing of grid 1 and the cathode, the cathode voltage exceeds that on grid 3 with respect to earth, grid current will flow in grid 3, damping the input circuit, unless the cathode current is cut-off by grid 1. The DC bias between grid 1 and cathode therefore should not be less than that required to cut-off the anode current.

In order to produce sufficient positive excursion of grid 1 and thereby furnish this DC bias, the oscillator grid resistor should be kept low in value; a nominal value (as shown in the circuits) of 22,000 ohms is recommended. The actual value used must be a compromise between that necessary to produce a large bias and the damping of the oscillator circuit.

The larger the positive swing on grid 1 the greater will be the peak anode current; the greater the peak anode current the higher will be the conversion conductance. Because, as mentioned earlier, the voltage between cathode and ground is applied in opposite phase to the signal grid, a large positive swing on grid 1 can only be advantageous if the cathode tap is very low down the coil. Care must be exercised that the position of this tap is not so low down the coil (in an effort to achieve high conversion) that there is danger of oscillation ceasing with low mains voltage, normal component variations or decreasing oscillator slope during the normal life of the valve. The peak voltage between cathode and earth should not in general be less than 1·5 volts or oscillation may be unreliable.

c. Long and Medium Waves: On wavebands up to about 6 Mc/s no difficulties should be experienced. With an oscillator grid current of 0·5 mA in 22,000 ohms at V_a 250 and V_{g2} 100 volts, the cathode tap should be adjusted to give about 2 volts peak between cathode and earth. This will result in a peak voltage between grid 1 and earth of 14 volts and such operation will result in optimum performance.

d. Short Waves: On short waves above about 6 Mc/s, due to the poor LC ratio with a normal gang condenser, it may be found difficult to obtain an oscillator grid current in 22,000 ohms of 0·5 mA, particularly at the low frequency end of the band. It is therefore best to adjust the cathode tap for optimum performance at the low frequency and allow some over-excitation at the high frequency end. This may result in lower conversion gain but will be partly made up by improved gain of the preceding signal frequency circuits. If a current of 0·5 mA cannot be achieved, good performance will result from a current of between 0·2 and 0·25 mA in 22,000 ohms with a tap position to give not less than 1·5 volts peak between cathode and earth although this may involve a slight control grid current. If parasitic oscillation occurs at the high frequency end of the waveband a resistor of 5 to 10 ohms in the grid 1 lead should be used.

e. VHF Bands: The valve may be employed quite successfully at frequencies of the order of 100 Mc/s as a self-excited oscillator and the circuit (Ref. 315·54) shows a typical arrangement to cover the international FM band.

The value of oscillator grid current will depend upon the efficiency of the oscillator circuit, and this current preferably should not be less than 0·2 mA and in no case less than 0·16 mA if operation is to be reliable with low mains voltages. The oscillator circuit wiring should be as direct as possible; in particular the lead from the cathode tap to the valve holder should be short as the inductance of this lead can cause considerable degeneration of the signal.

In order to avoid modulation hum and microphonics the heater should be operated at cathode potential either by means of RF chokes or the lead inter-wound with the coil.

As the screening of grid 2 is imperfect at very high frequencies, considerable oscillator voltage will appear on the control grid, resulting in appreciable grid current so that the use of A.V.C. is not advised on frequencies in the region of 100 Mc/s.

2. AUTOMATIC VOLUME CONTROL: A.V.C. may be applied to the control grid and the relationship between this voltage and the conversion conductance and anode impedance is shown in the characteristic curves (Ref. 315·4 and 315·5). The DC resistance between control grid and chassis should be kept as low as is practicable and preferably should not exceed a value of 1 megohm. When the valve is employed as a self-excited oscillator the recommendations as regards heterodyne voltage should be observed carefully otherwise control grid current will flow, resulting in low gain of this valve and possibly low gain from other valves connected to the A.V.C. line, due to the negative voltage on the A.V.C. line generated by the grid current. When the valve is employed at high frequencies of the order of 30 Mc/s and above, the use of A.V.C. is not advised.

3. SCREEN VOLTAGE: The screen voltage employed on the valve is not very critical but, in general, best results are obtained with a voltage between 70 and 100 volts. The characteristic curves (Ref. 315·4, 315·5 and 315·6) show the variation in conversion conductance and anode impedance with several values of screen voltage. Because various sample valves may show a fairly wide variation in screen current it is preferable to supply this voltage from a potentiometer rather than a series resistor. This is more particularly so when other RF and IF amplifier valves derive their screen voltage from the same point, as a change in the frequency changer valve may well alter the operating screen voltage of other valves hence give a wider spread in gain than would otherwise be the case. A potentiometer to supply this valve and the IF amplifier should employ such values that the lower limb consumes a fixed drain of approximately 5 to 10 mA.

HIGH FREQUENCY PERFORMANCE

The valves may be operated either with a separate or self-excited oscillator up to a frequency of the order of 100 Mc/s.

1. INPUT IMPEDANCE and INPUT CAPACITY: The change in input impedance and input capacity resulting from changes in control grid voltage are shown in curves attached to this report. Curve No. 315·8 shows the operation at a frequency of 18 Mc/s. At VHF the input impedance varies considerably with the circuit constants and layout; no value can be quoted reliably but the capacity change is of the same order as that at 18 Mc/s. As normally employed, the input resistance is negative, and in consequence a stopper resistance in the control grid is frequently essential to avoid instability.

2. FREQUENCY DRIFT OF THE OSCILLATOR:

a. Drift with A.V.C.: A curve is attached to this report (Ref. 315·10) which shows the relationship between the oscillator frequency and the voltage applied to the control grid, the other electrode voltages remaining constant. If the regulation of these other voltages is poor the frequency drift may be increased.

b. Drift with Line Voltage Variations: A curve is attached (Ref. 315·11) which shows the relationship between the oscillator frequency and the line voltage applied. This variation includes that due to all electrode voltages including the heater.

c. Drift due to Warming-up of the Valve: A curve is attached (Ref. 315·12) which shows the frequency drift of the oscillator plotted against time. This curve shows the drift of the valve alone, and assumes that the receiver is already hot and no drift occurs in the values of the components or in the line voltage.

TYPICAL CIRCUIT CONSIDERATIONS

When the valve is used under self-excited oscillator conditions as mentioned above, the oscillator coil design is somewhat critical. The circuit (Ref. 315·55) attached is typical of long, medium and short wave practice. Typical coil design is shown on data (Ref. 315·56) and that for the VHF band on the circuit drawing (Ref. 315·54) together with the necessary coil winding data.

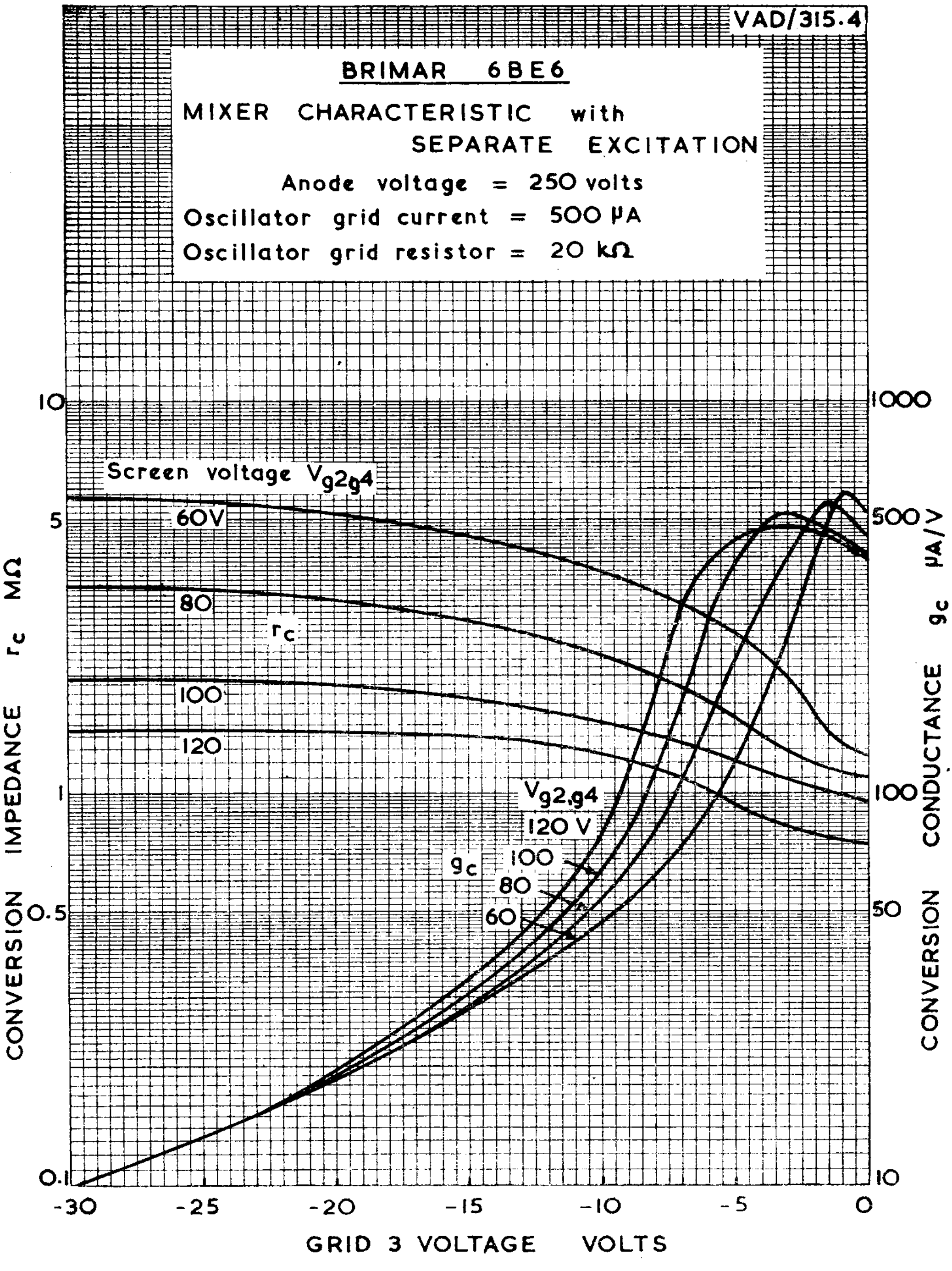
Curves showing the conversion gain and oscillator grid current using the specified coils over the various wavebands are covered on Curves Nos. 315·15, 315·16 and 315·17.

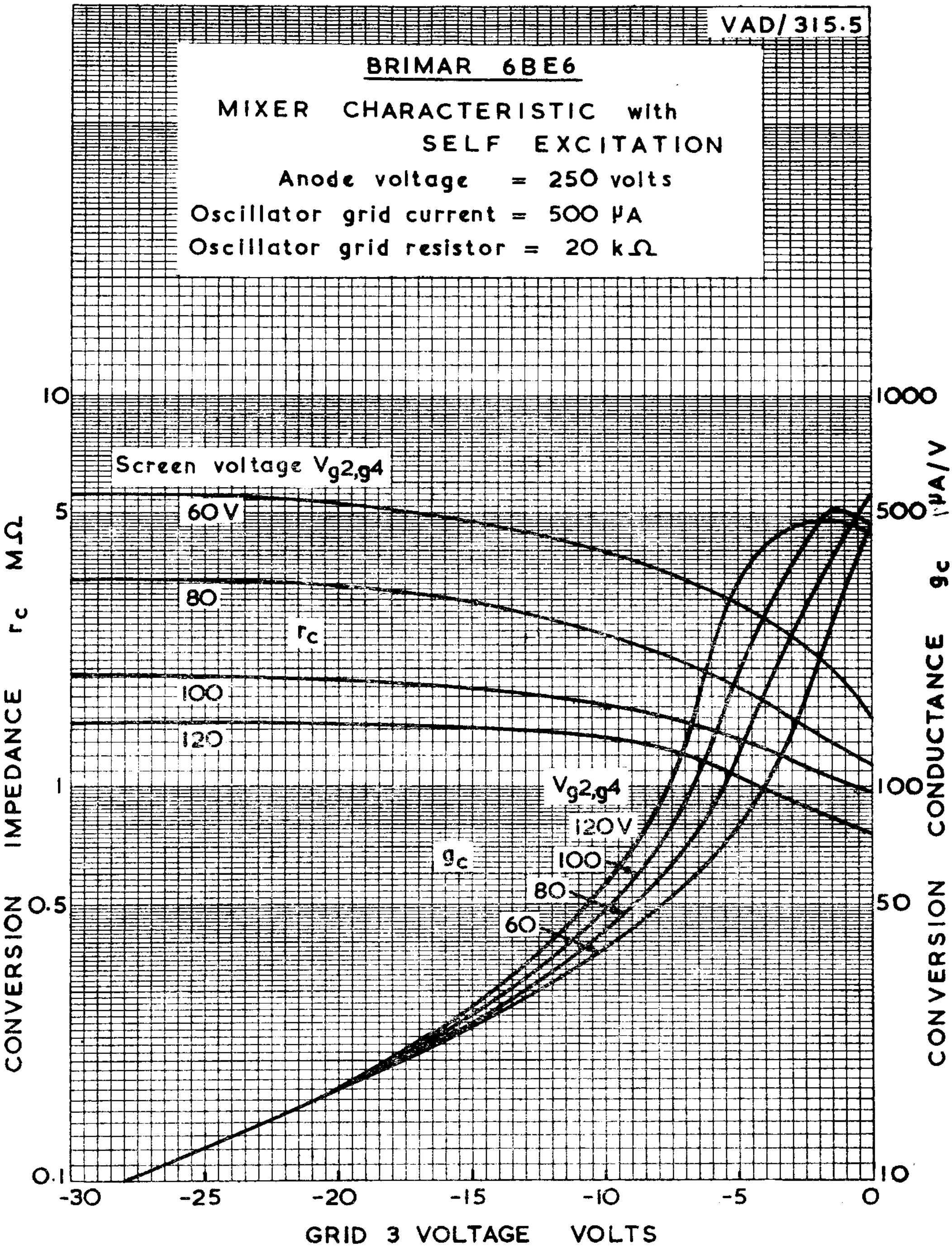
OPERATION AS AN AF MIXER OR IN VOLUME EXPANSION OR CONTRACTION CIRCUITS

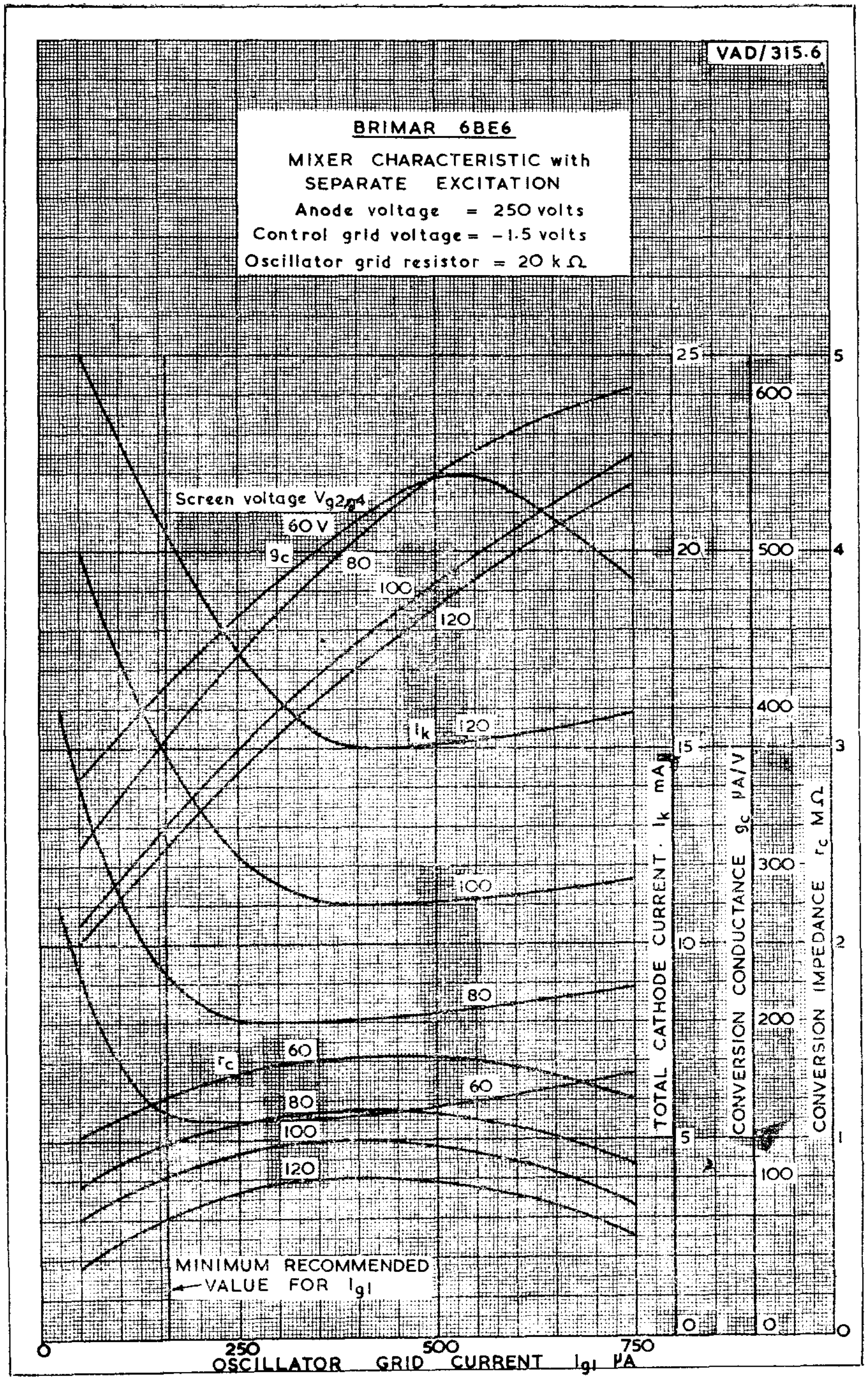
As the valve has two grids capable of being used to control the anode current it is quite suitable for use as an AF mixer or one or other of the grids can be controlled by a DC bias.

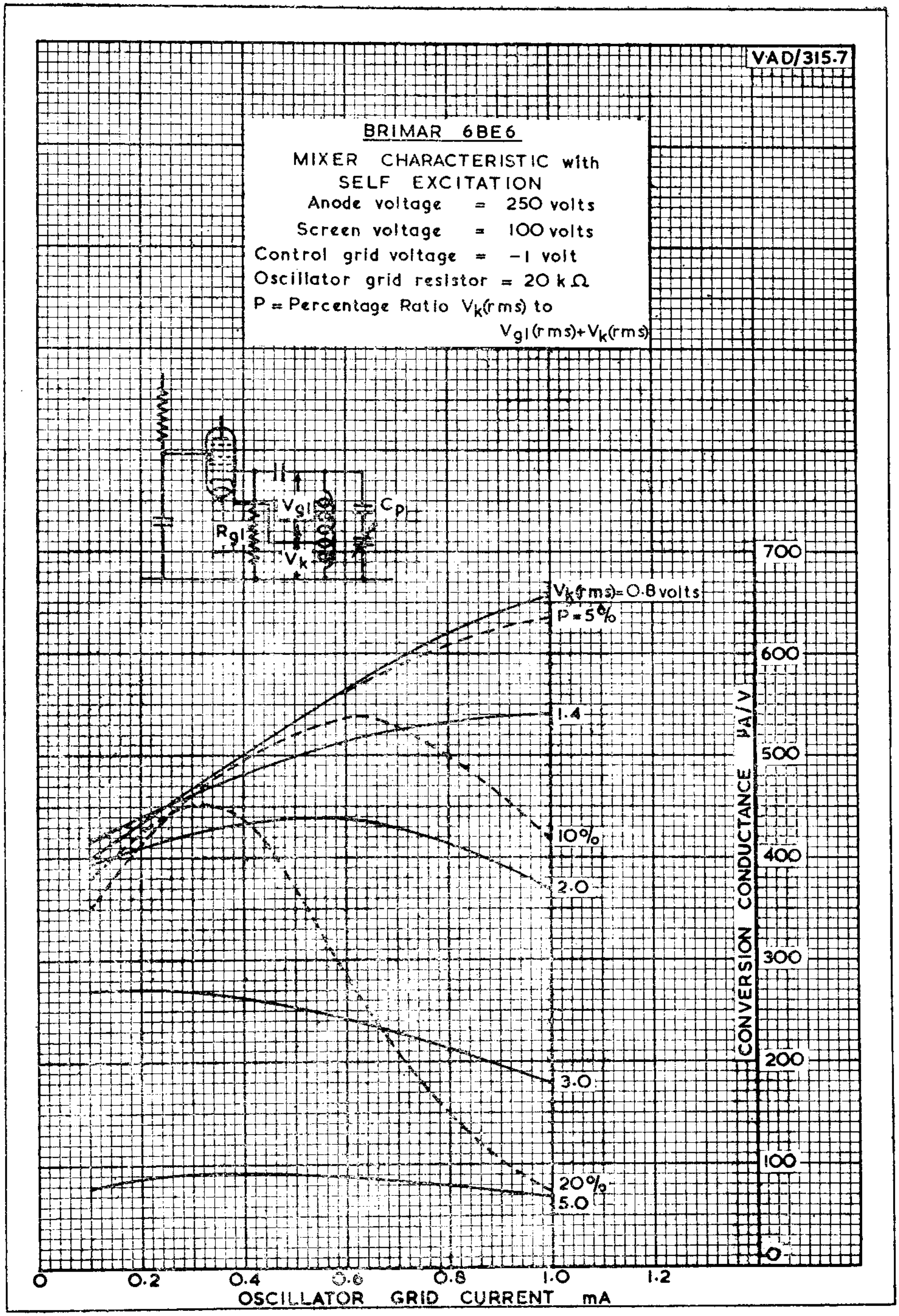
Curves Nos. 315·13 and 315·14 are attached which show the relationship between anode current and screen current with negative bias on either grid 1 or grid 3.

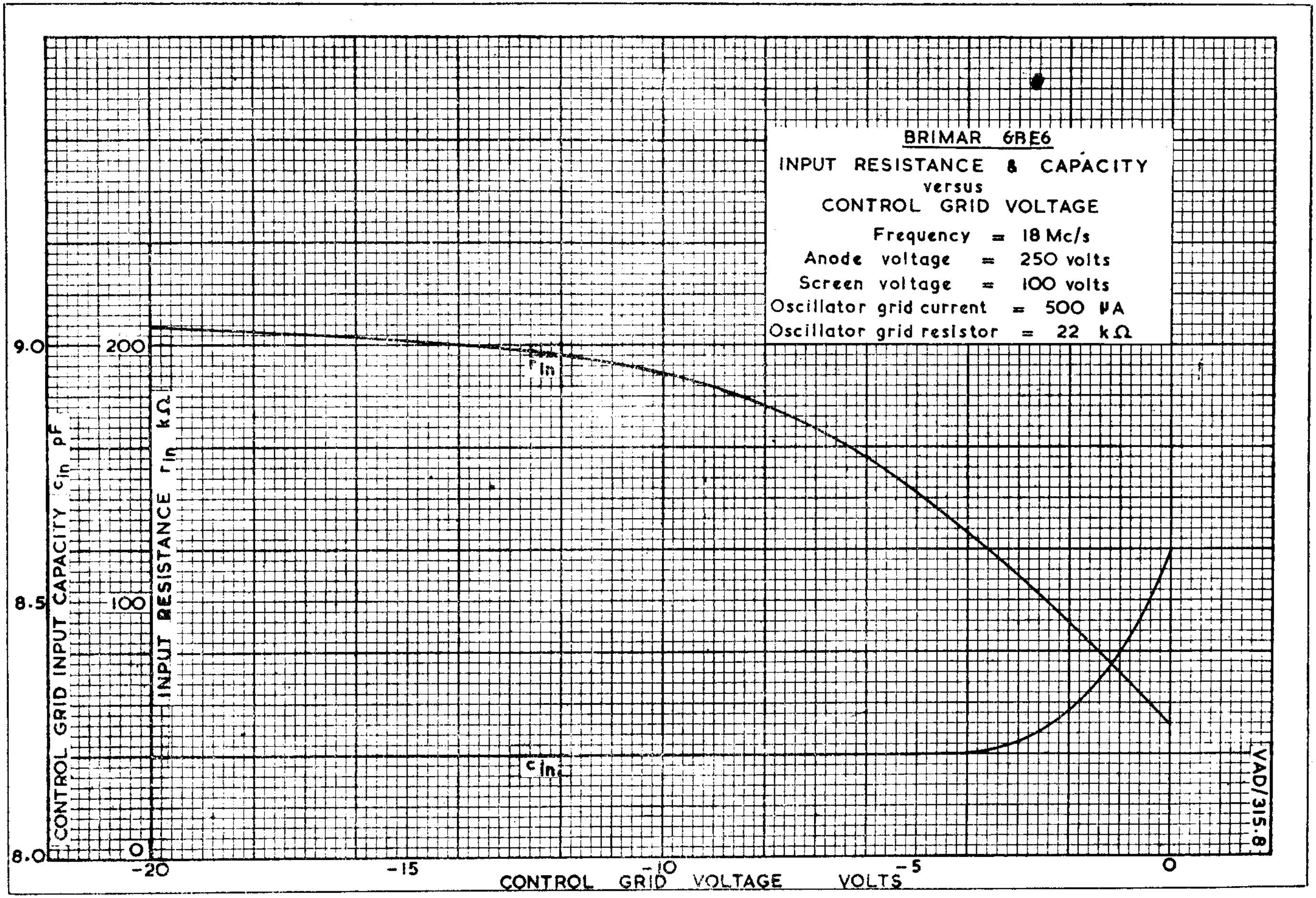
Data Ref. 315·57 show a circuit for use as an AF mixer with typical values and the stage gain from either grid and the RMS output voltage. When the valve is used in volume expander applications grid 3 should be used for control purposes.


VAD/315.4
BRIMAR 6BE6
MIXER CHARACTERISTIC with SEPARATE EXCITATION
Anode voltage = 250 volts
Oscillator grid current = 500 μA
Oscillator grid resistor = 20 kΩ
Screen voltage Vg2g4
60V
80
rc
100
120
Vg2,g4
120 V
gc
100
80
60
CONVERSION IMPEDANCE rc MΩ
CONVERSION CONDUCTANCE gc μA/V
GRID 3 VOLTAGE VOLTS

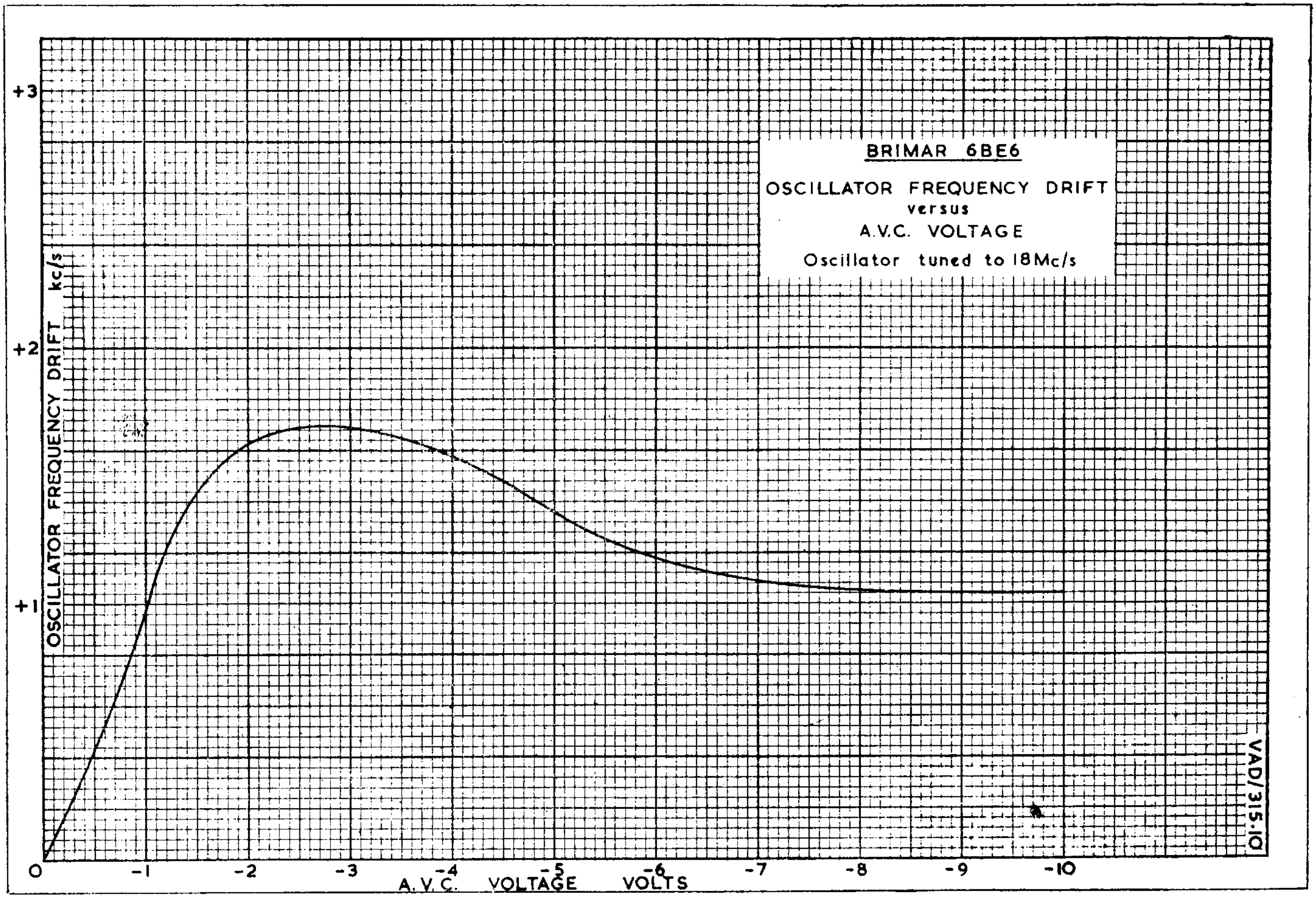

VAD/315.5
BRIMAR 6BE6
MIXER CHARACTERISTIC with SELF EXCITATION
Anode voltage = 250 volts
Oscillator grid current = 500 μA
Oscillator grid resistor = 20 kΩ
Screen voltage Vg2,g4
60V
80
100
120
rc
gc
Vg2,g4
120V
100
80
60
10
5
1
0.5
0.1
1000
500
100
50
10
-30
-25
-20
-15
-10
-5
0
CONVERSION IMPEDANCE rc MΩ
CONVERSION CONDUCTANCE gc μA/V
GRID 3 VOLTAGE VOLTS


VAD/315.6
BRIMAR 6BE6
MIXER CHARACTERISTIC with
SEPARATE EXCITATION
Anode voltage = 250 volts
Control grid voltage = -1.5 volts
Oscillator grid resistor = 20 kΩ
Screen voltage Vg2g4
60 V
gc
80
100
120
Ik
120
100
80
rc
60
60
80
100
120
MINIMUM RECOMMENDED
VALUE FOR Ig1
TOTAL CATHODE CURRENT . Ik mA
CONVERSION CONDUCTANCE gc µA/V
CONVERSION IMPEDANCE rc MΩ
25
20
15
10
5
0
600
500
400
300
200
100
0
5
4
3
2
1
0
0
250
500
750
OSCILLATOR GRID CURRENT Ig1 µA

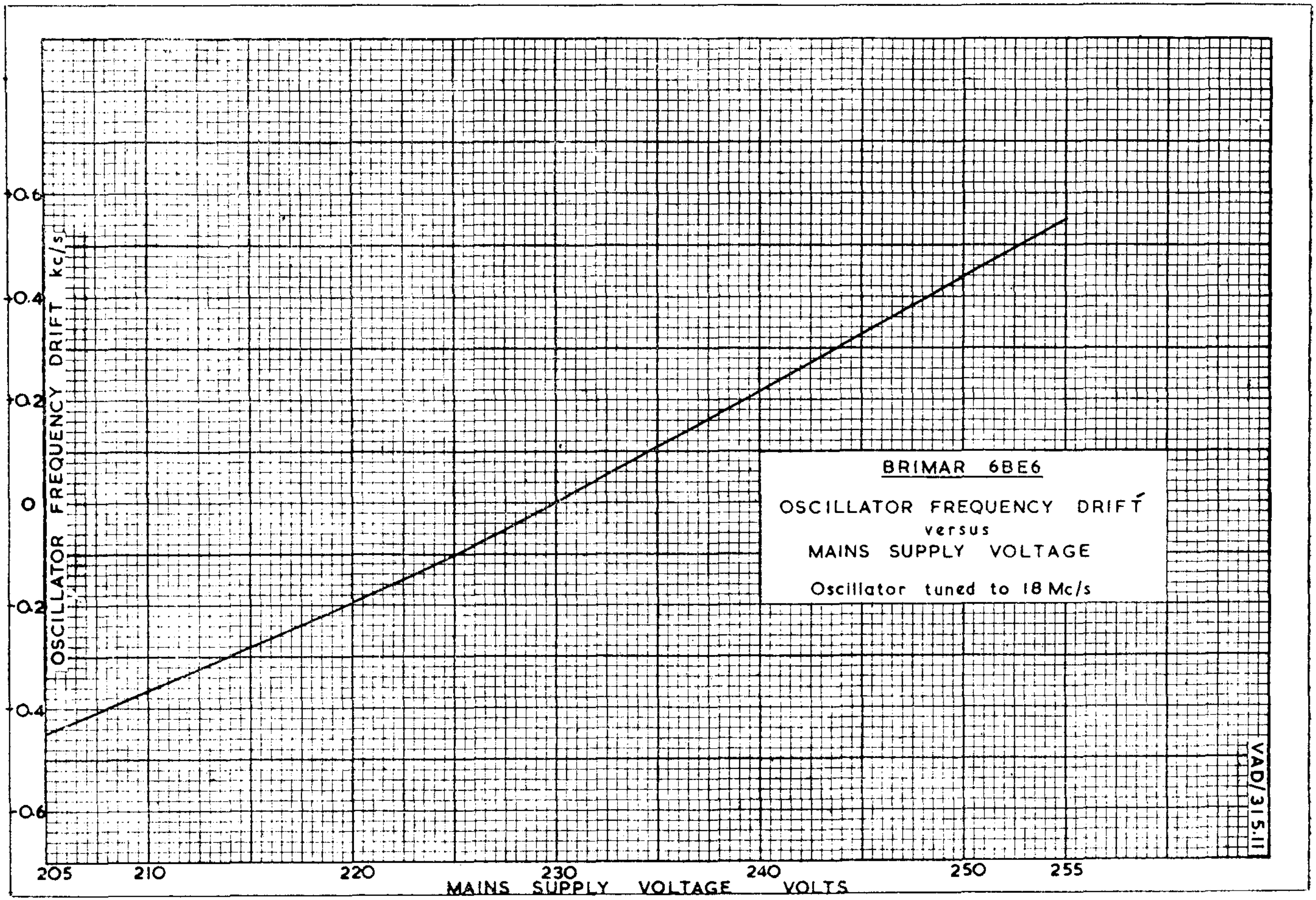

VAD/315.7
BRIMAR 6BE6
MIXER CHARACTERISTIC with
SELF EXCITATION
Anode voltage = 250 volts
Screen voltage = 100 volts
Control grid voltage = -1 volt
Oscillator grid resistor = 20 kΩ
P = Percentage Ratio Vk(rms) to Vg1(rms)+Vk(rms)
Rg1
Vg1
Vk
Cp
Vk(rms)=0.8 volts
P=5%
1.4
10%
2.0
3.0
20%
5.0
700
600
500
400
300
200
100
0
CONVERSION CONDUCTANCE µA/V
0
0.2
0.4
0.6
0.8
1.0
1.2
OSCILLATOR GRID CURRENT mA



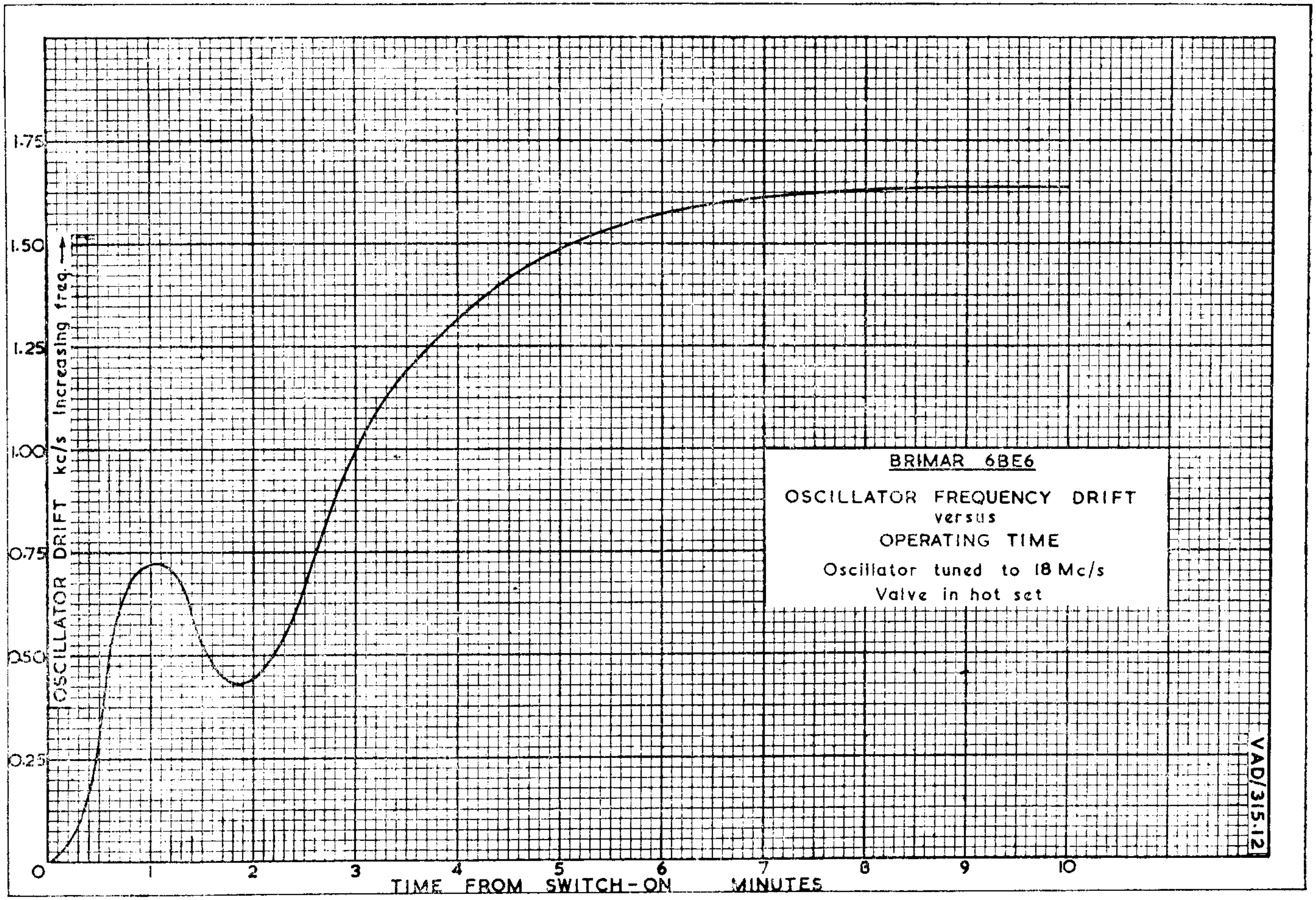
BRIMAR 6BE6
INPUT RESISTANCE & CAPACITY
versus
CONTROL GRID VOLTAGE
Frequency = 18 Mc/s
Anode voltage = 250 volts
Screen voltage = 100 volts
Oscillator grid current = 500 μA
Oscillator grid resistor = 22 kΩ
CONTROL GRID INPUT CAPACITY c_{in} pF
INPUT RESISTANCE r_{in} kΩ
r_{in}
c_{in}
9.0
8.5
8.0
200
100
0
-20
-15
-10
-5
0
CONTROL GRID VOLTAGE VOLTS
VAD/315.8

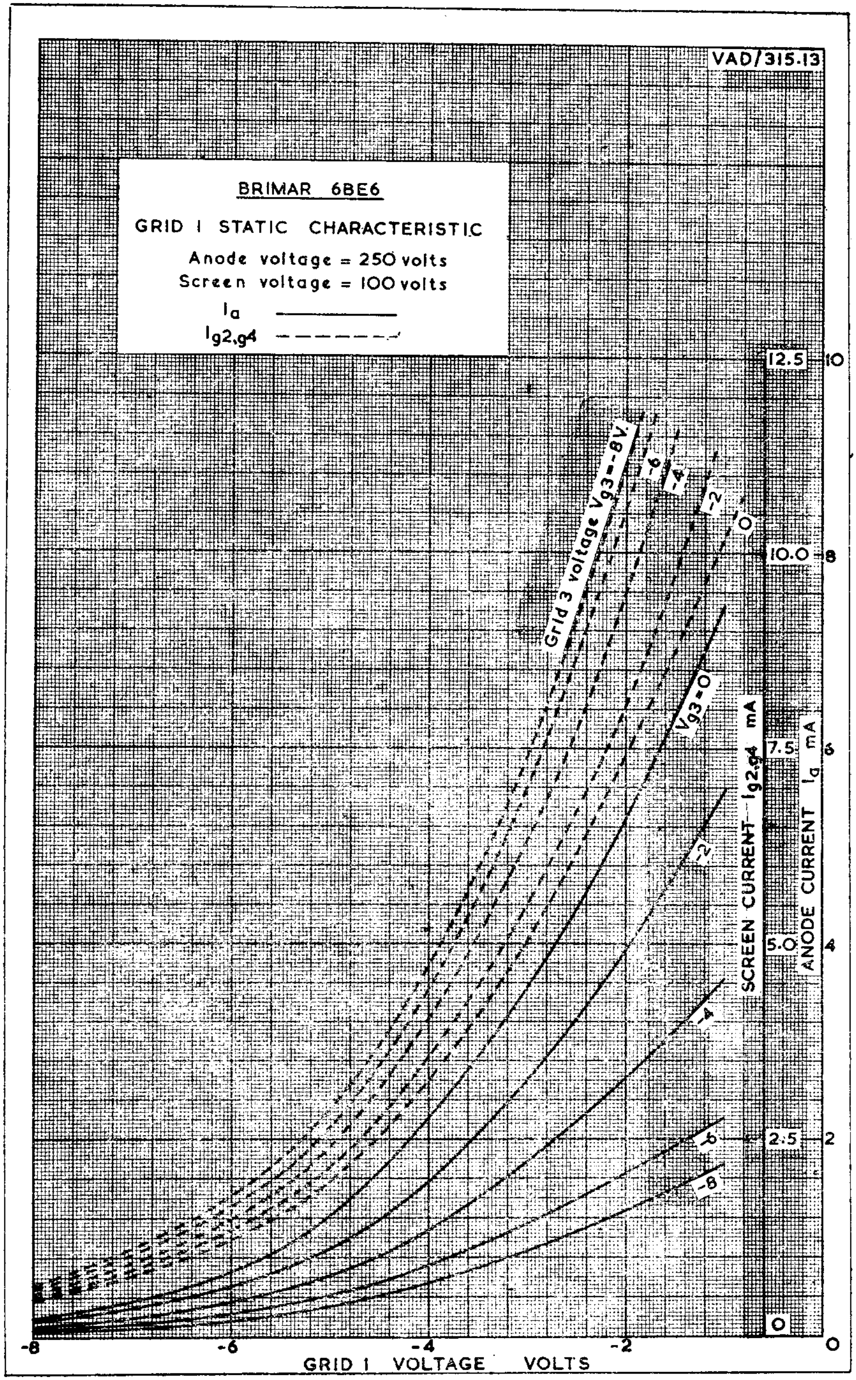


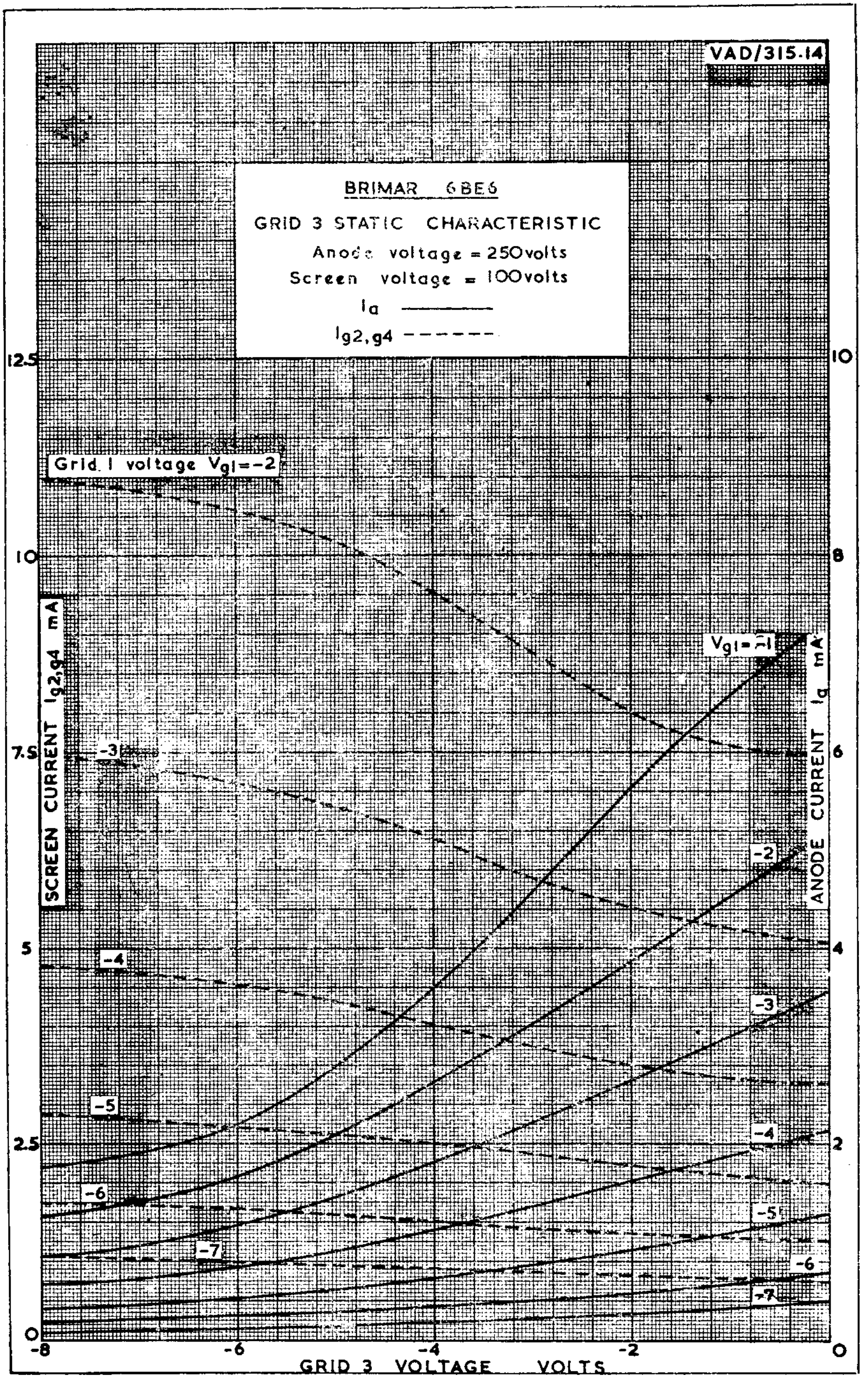
BRIMAR 6BE6
OSCILLATOR FREQUENCY DRIFT
versus
A.V.C. VOLTAGE
Oscillator tuned to 18Mc/s
OSCILLATOR FREQUENCY DRIFT kc/s
+3
+2
+1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
A.V.C. VOLTAGE VOLTS
VAD/315.10

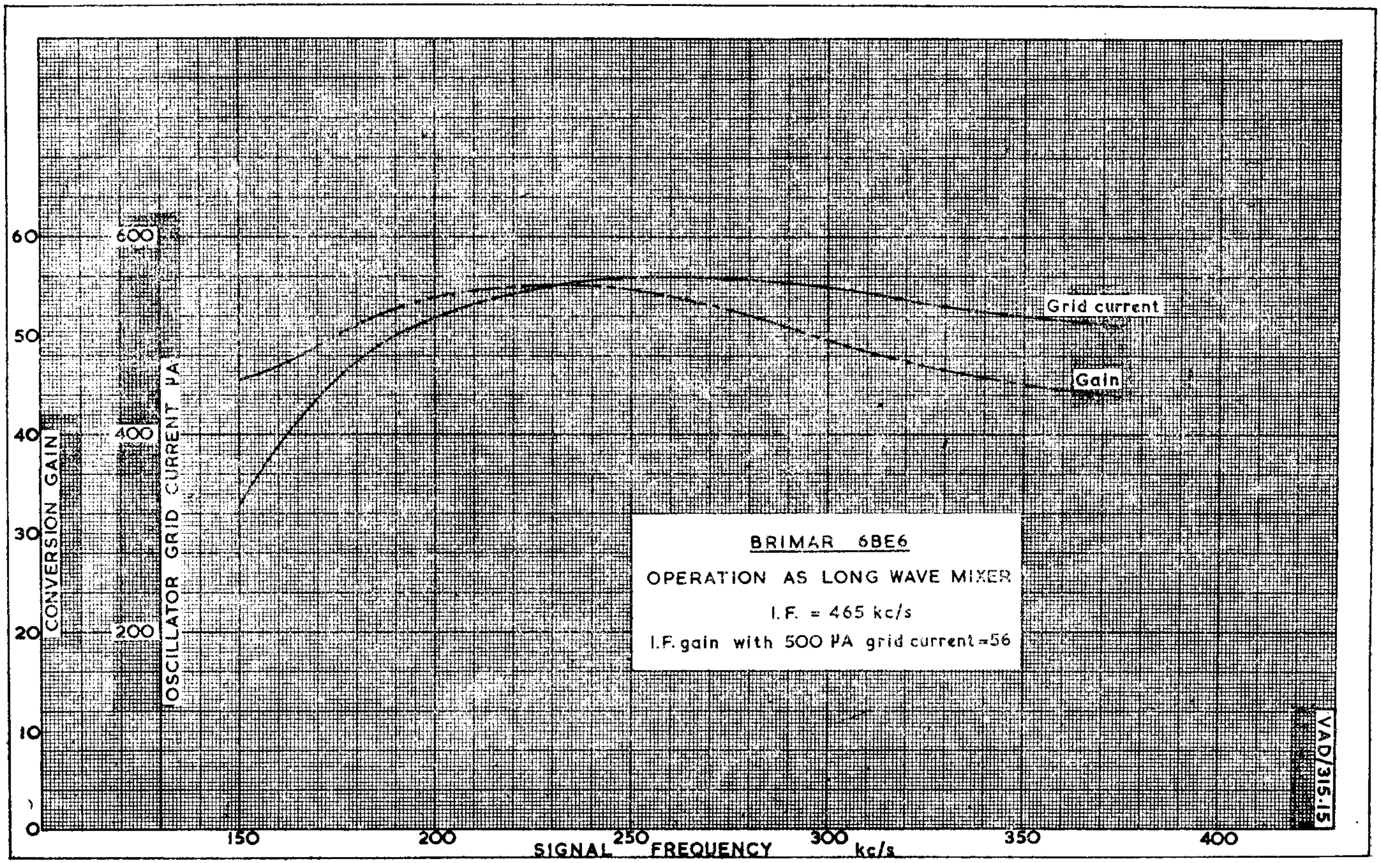


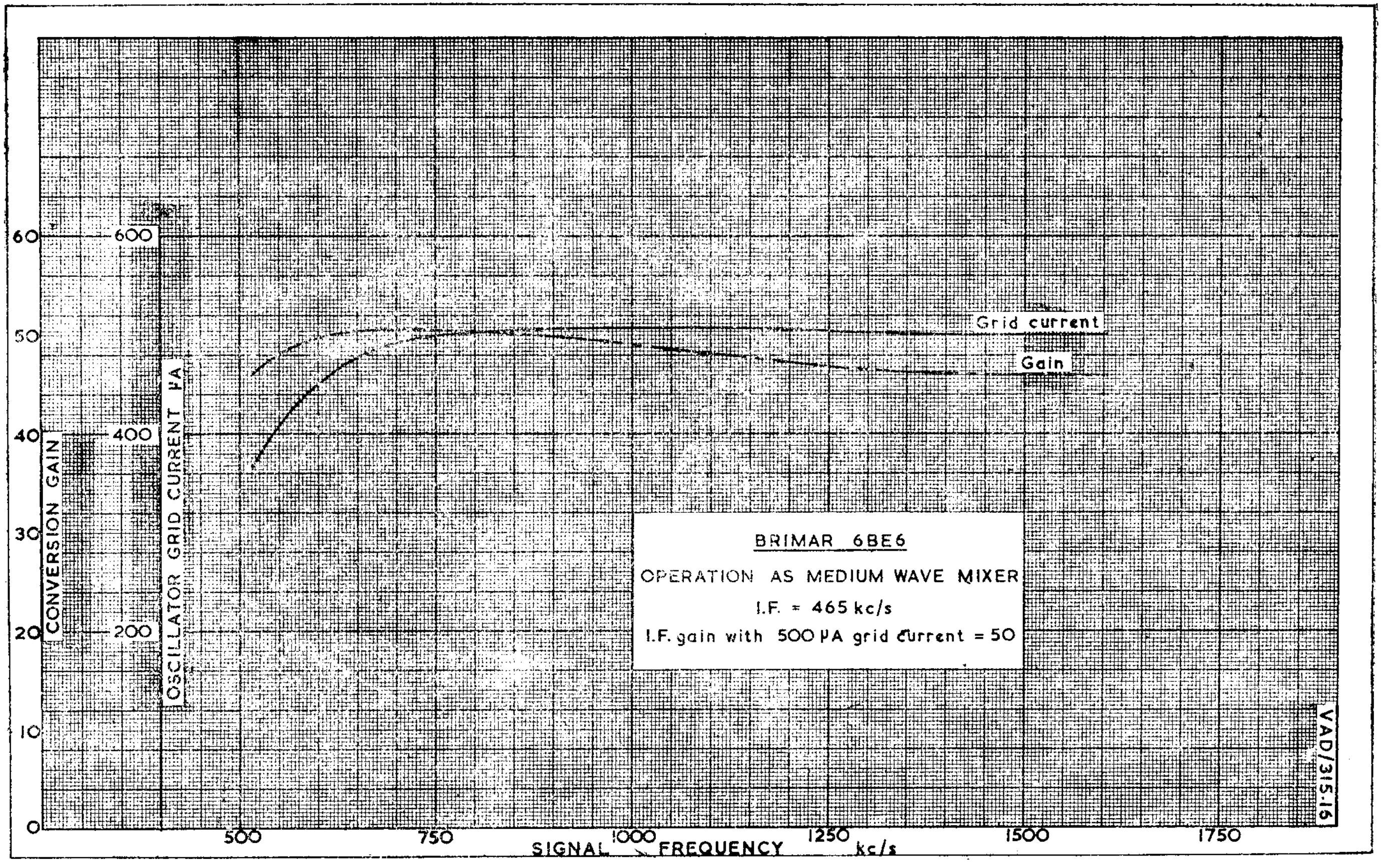
BRIMAR 6BE6
OSCILLATOR FREQUENCY DRIFT
versus
MAINS SUPPLY VOLTAGE
Oscillator tuned to 18 Mc/s
OSCILLATOR FREQUENCY DRIFT kc/s
0.6
0.4
0.2
0
0.2
0.4
0.6
205
210
220
230
240
250
255
MAINS SUPPLY VOLTAGE VOLTS
VAD/315.11

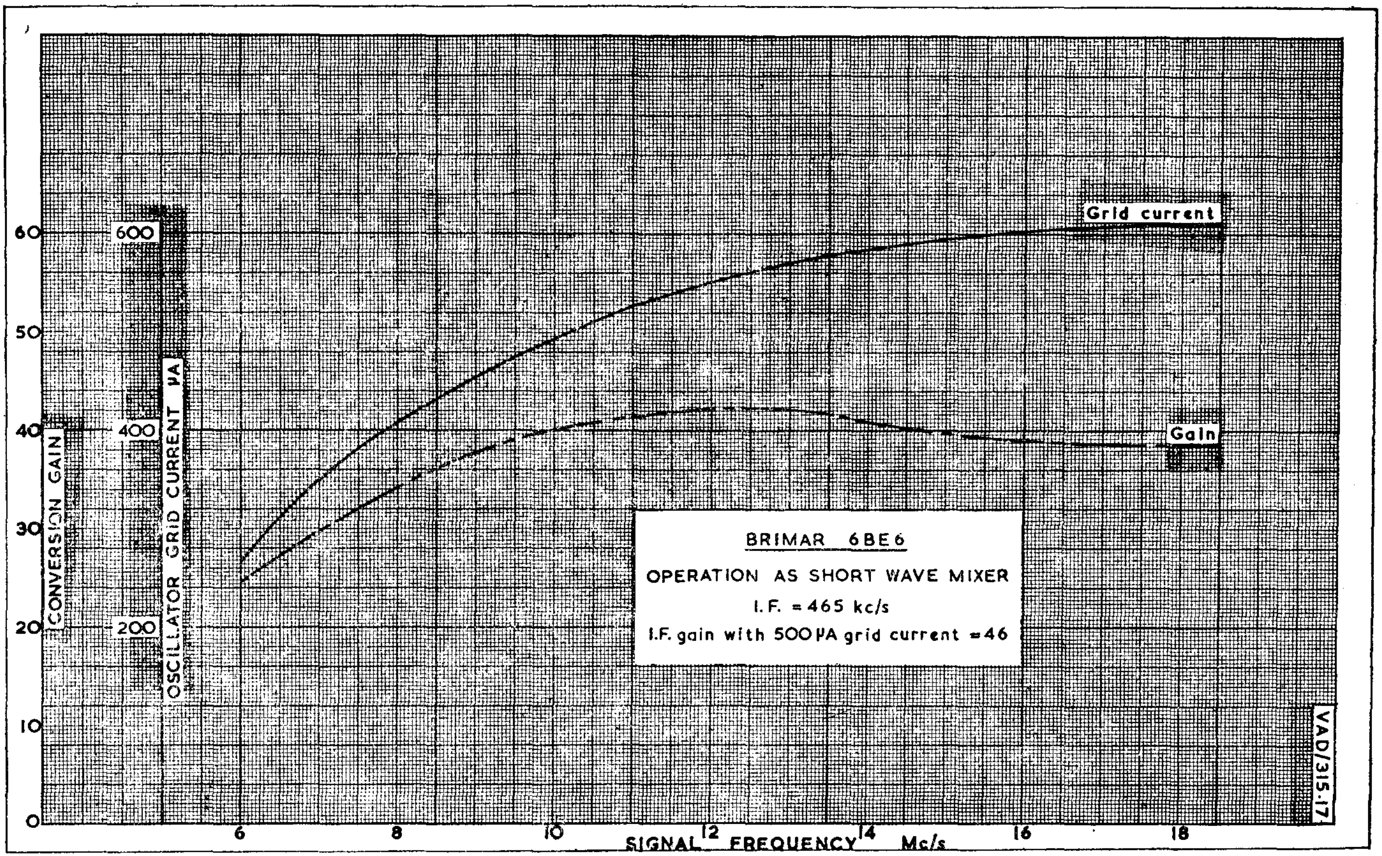

BRIMAR 6BE6
OSCILLATOR FREQUENCY DRIFT
versus
OPERATING TIME
Oscillator tuned to 18 Mc/s
Valve in hot set
OSCILLATOR DRIFT kc/s Increasing freq. →
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0
1
2
3
4
5
6
7
8
9
10
TIME FROM SWITCH-ON MINUTES
VAD/315.12


VAD/315.13
BRIMAR 6BE6
GRID I STATIC CHARACTERISTIC
Anode voltage = 250 volts
Screen voltage = 100 volts
Ia
Ig2,g4
Grid 3 voltage Vg3 = -8V.
-6
-4
-2
0
Vg3 = 0
-2
-4
-6
-8
12.5
10.0
7.5
5.0
2.5
0
10
8
6
4
2
0
SCREEN CURRENT Ig2,g4 mA
ANODE CURRENT Ia mA
-8
-6
-4
-2
0
GRID I VOLTAGE VOLTS


VAD/315.14
BRIMAR 6BE6
GRID 3 STATIC CHARACTERISTIC
Anode voltage = 250volts
Screen voltage = 100volts
I_a
$I_{g2,g4}$
Grid 1 voltage V_{g1}=-2
V_{g1}=-1
-3
-4
-5
-6
-7
-2
SCREEN CURRENT $I_{g2,g4}$ mA
ANODE CURRENT I_a mA
GRID 3 VOLTAGE VOLTS
12.5
10
7.5
5
2.5
0
8
6
4
2
-8
-6
-4
-2

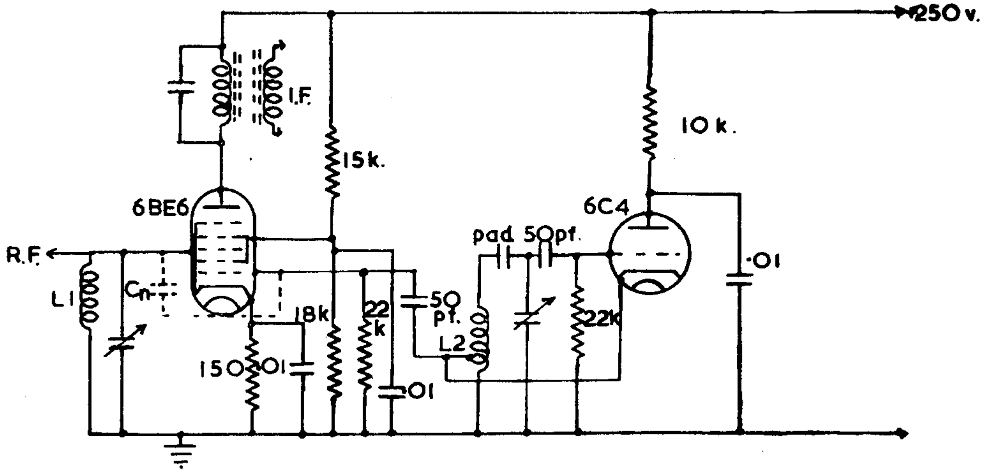

BRIMAR 6BE6
OPERATION AS LONG WAVE MIXER
I.F. = 465 kc/s
I.F. gain with 500 μA grid current = 56
Grid current
Gain
CONVERSION GAIN
OSCILLATOR GRID CURRENT μA
SIGNAL FREQUENCY kc/s
0
10
20
30
40
50
60
200
400
600
150
200
250
300
350
400
VAD/315.15


BRIMAR 6BE6
OPERATION AS MEDIUM WAVE MIXER
I.F. = 465 kc/s
I.F. gain with 500 μA grid current = 50
Grid current
Gain
CONVERSION GAIN
OSCILLATOR GRID CURRENT μA
SIGNAL FREQUENCY kc/s
0
10
20
30
40
50
60
200
400
600
500
750
1000
1250
1500
1750
VAD/315.16



BRIMAR 6BE6
OPERATION AS SHORT WAVE MIXER
I.F. = 465 kc/s
I.F. gain with 500 μA grid current = 46
Grid current
Gain
CONVERSION GAIN
OSCILLATOR GRID CURRENT μA
600
400
200
0
10
20
30
40
50
60
6
8
10
12
14
16
18
SIGNAL FREQUENCY Mc/s
VAD/315.17

BRIMAR 6BE6 CONVERTER, SEPARATELY EXCITED BY 6C4 OSCILLATOR

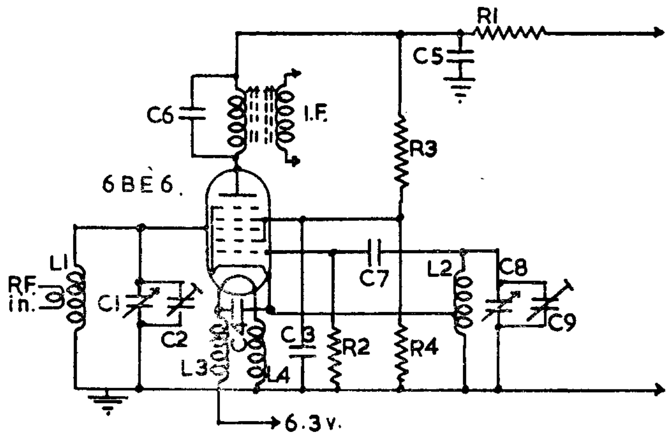


Position of tap on L2 adjusted for required 6BE6 g1 current.

VAD/315.53

VAD/315.54

BRIMAR 6BE6 SELF EXCITED CONVERTER CIRCUIT FOR V.H.F. BAND 88 TO 108 MC/S



L1, L2. 1 3/4 turns, 16 S.W.G. tinned copper. Dia. 3/4", spacing between turns 3/8". Position of cathode tap on L2 is dependent on circuit layout.

C1, C8. 2 gang 7.5 to 18 pf. variable condenser.

C2, C9. Trimmers 15 pf. maximum.

L3, L4. 26 turns of 18 S.W.G. close wound on a 3/8" dia. former.

C3,4,5. 1000 pf.

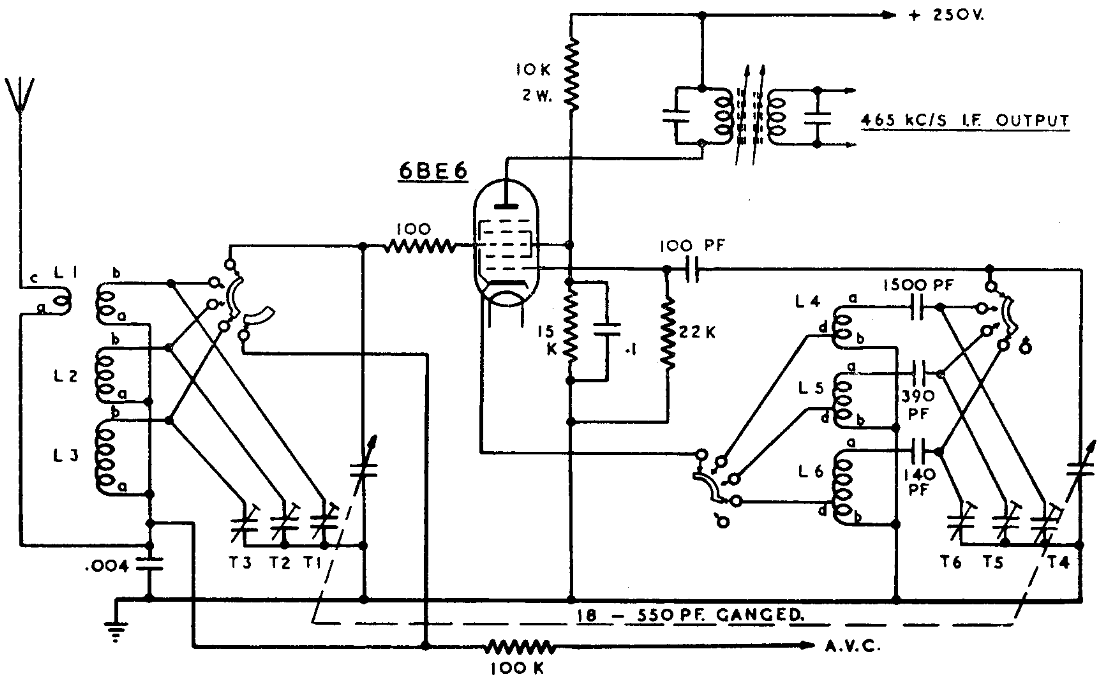
C7. 25 pf.

R1. 1000 Ω.

R2. 22 kΩ.

R3. 15 kΩ. R4. 18 kΩ.

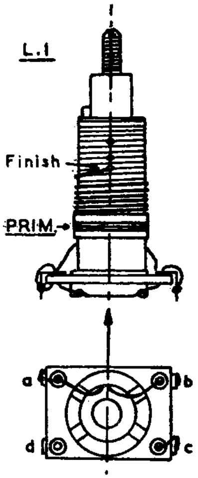
BRIMAR 6BE6 LONG, MEDIUM & SHORT WAVE CONVERTER CIRCUIT



VAD/315.55

BRIMAR 6BE6

SHORT-WAVE COIL DATA



L = 1·42 μH
Q at 10 Mc/s = 82

S.W. AERIAL

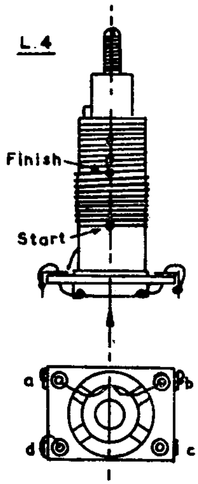
Former: 1/2″ outside diameter moulded bakelite, threaded 10 turns per cm.

Iron Dust Core: Neosid Z.11.B.

Secondary: 9 turns of 22 SWG En. Cu. wound in grooving, clockwise from start in direction of arrow.
Start taken through hole in former to tag "a".
Finish taken through hole in former to tag "b".

Primary: 4 turns of 38 SWG D.S.C.Cu. close wound on two layers of Bitumenised paper, 3/16″ wide, placed over the earthy end of the coil, clockwise from start in direction of arrow.
Start taken to tag "c".
Finish taken to tag "a".

Trimmer: T.1. 4—40 pF.



L = 1·57 μH
Q at 10 Mc/s = 120

S.W. OSCILLATOR

Former: As for L.1.

Iron Dust Core: As for L.1.

Winding: 10 turns of 22 SWG En. Cu. wound in grooving, clockwise from start in direction of arrow.

Start taken through hole in former to tag "b".

Finish taken through hole in former to tag "a".

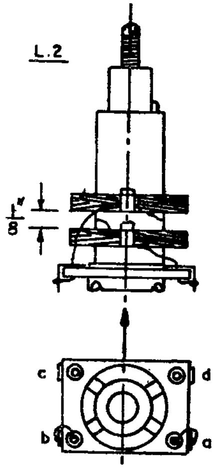
Tap at 1-5/8 turns from start taken to tag "d".

Trimmer: T.4. 4—40 pF.

BRIMAR 6BE6

MEDIUM-WAVE COIL DATA

L.2



L = 193·5 μH

Q at 1 Mc/s = 160

M.W. AERIAL

Former: 1/2″ outside diameter, moulded bakelite.

Iron Dust Core: Neosid Z.11.B.

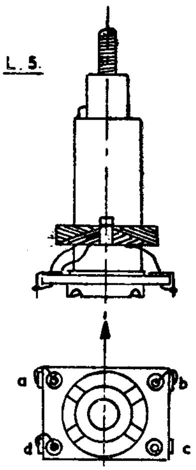
Winding: 57 + 57 turns of 30/48 Litz, in two sections 1/8″ wide, spaced 1/8″ as shown in diagram.

Single-Wave wound.
Start taken to tag "a".
Finish taken to tag "b".

Gears (Douglas): 50—32—34—50/60-60.

Trimmer: T.2. 4—40 pF.

L. 5.



L = 120·5 μH

Q at 1 Mc/s = 44

M.W. OSCILLATOR

Former: As for L.2.

Iron Dust Core: As for L.2.

Winding: 70 turns of 38 D.S.C. Cu. tapped at 6 turns.

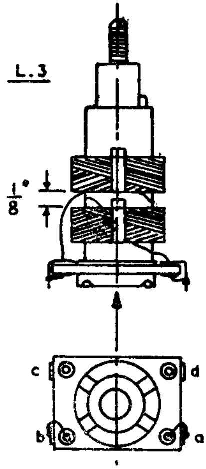
Double-Wave wound, 1/8″ wide.
Start taken to tag "b".
Finish taken to tag "a".
Tap taken to tag "d".

Gears (Douglas): 50-41-42-50/40-80.

Trimmer: T.5. 4—40 pF.

BRIMAR 6BE6

LONG-WAVE COIL DATA



L = 2·19 mH

Q at 200 kc/s = 66

L.W. AERIAL

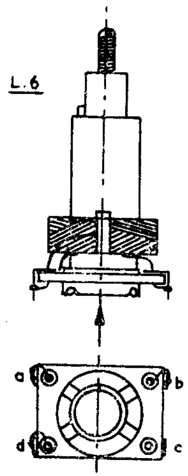
Former: 1/2″ outside diameter, moulded bakelite.

Iron Dust Core: Neosid Z.11.B.

Winding: 220 + 220 turns of 38 SWG D.S.C. in two sections.
Single-Wave wound, 1/4″ wide, spaced 1/8″ as shown in diagram.
Start taken to tag "a".
Finish taken to tag "b".

Gears (Douglas): 50-41-42-50/60-60.

Trimmer: T.3. 40—80 pF.



L = 0·62 mH

Q at 500 kc/s = 62

L.W. OSCILLATOR

Former: As for L.3.

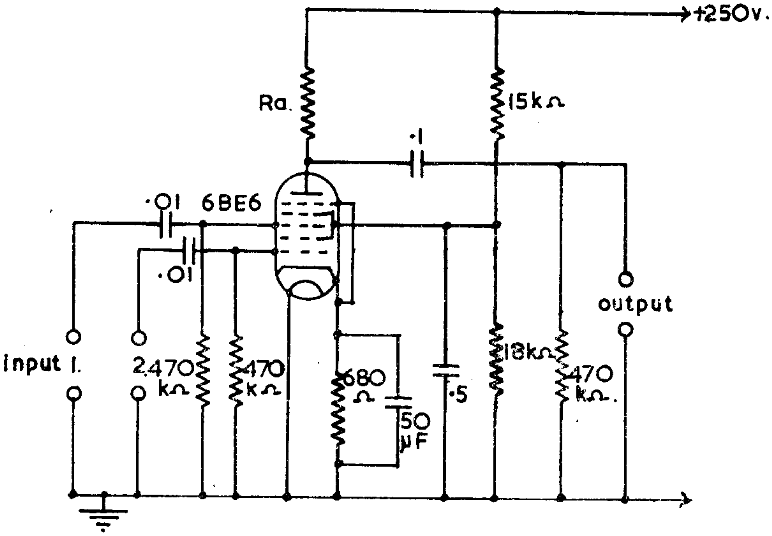
Iron Dust Core: Diameter 10 mm. Length 17 mm. with 4BA brass screw insert 1″ long.

Winding: 150 turns of 38 SWG D.S.C. Cu. tapped at 8 turns.
Single-Wave wound, 1/4″ wide.
Start taken to tag "b".
Finish taken to tag "a".
Tap taken to tag "d".

Gears (Douglas): 50-41-42-50/60-60.

Trimmer: T.6. 40—80 pF.

BRIMAR 6BE6 A.F. MIXER CIRCUIT



	gain for 5v.R.M.S. output.		maximum output.	
	input 1.	input 2.	input 1.	input 2.
Ra 47kΩ	7.5	25	45	40
Ra 100kΩ	11	36	70	60

BRIMAR

RECEIVING VALVE

6BR7

APPLICATION REPORT VAD/508.3

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

Issued October, 1951. Reprinted January, 1952.

1.0 INTRODUCTION: The Brimar 6BR7 is a single ended indirectly heated screened pentode of miniature construction intended for use where low AF noise, microphony and hum are required, as in early stages of high gain AF amplifiers. The heater is intended for operation in parallel with those of other valves in AC operated equipment.

Very effective internal screening is employed, but the input and output capacitances are low enough to allow the valve to be used in RF applications up to frequencies of at least 20 Mc/s.

In this report are characteristic curves and details of the performance of the valve as a resistance capacity coupled amplifier. The anticipated levels of hum, hiss and microphony are given and the precautions necessary to ensure the best performance are discussed.

2.0 DESCRIPTION: The valve is a miniature screened pentode with characteristics similar in most ways to those of the 6J7 valve. The structure is mounted in a T6½ bulb and is fitted with a B9A (Noval) base. The whole assembly is designed with a view to obtaining the utmost possible rigidity. The control grid is screened internally from the heater to eliminate hum due to electrostatic pick-up from that source. The heater is wound in the form of a double spiral to reduce, as far as possible, the magnetic field set up by the heater current.

3.0 CHARACTERISTICS:

3.1 Cathode:	Indirectly heated	
	Voltage	6·3 volts
	Current (nominal)	0·15 ampere
	Max. DC Heater-Cathode potential	100 volts
3.2 Dimensions:	Max. Overall Length	2-3/16 ins.
	Max. Diameter	7/8 in.
	Max. Seated Height	1-15/16 ins.
3.3 Base: Type B9A (Noval):	Pin 1 No Connection NC	
	Pin 2 Control Grid g_1	
	Pin 3 Cathode k	
	Pin 4 Heater h	
	Pin 5 Heater h	
	Pin 6 Internal Shield s	
	Pin 7 Anode a	
	Pin 8 Screen Grid g_2	
	Pin 9 Suppressor Grid g_3	

3.4 Ratings (Design Centre):

PENTODE CONNECTED:

Max. Anode Voltage	300 volts
Max. Screen Voltage	125 volts
Max. Anode Dissipation	0·75 watts
Max. Screen Dissipation	0·3 watts

TRIODE CONNECTED (g_2 connected to anode, g_3 connected to cathode):

Max. Anode Voltage	250 volts
Max. Anode Dissipation	1·75 watts

3.5 Inter-electrode Capacitances (measured with no external shield):

PENTODE CONNECTED:

C_{in}	4·25 pF
C_{out}	4·0 pF
$C_{g1,a}$	0·01 pF max.

TRIODE CONNECTED:

C_{in}	3·2 pF
C_{out}	6·7 pF
$C_{g,a}$	1·1 pF

3.6 Characteristic Curves: Curves are included in this report which show:

Anode current versus anode voltage (I_a/V_a) at various values of control grid voltage with a screen voltage (V_{g2}) of 125 volts, No. 308·215. Similar curves for a screen voltage of 100 volts are shown on No. 308·216, for V_{g2} 75 volts, No. 308·217 and for V_{g2} 50 volts, No. 308·218.

Anode current versus control grid voltage at various values of screen grid voltage, No. 308·220.

Anode current versus anode voltage with the valve connected as a triode, No. 308·219.

Mutual conductance and impedance versus control grid voltage for the valve connected as a pentode No. 308·221.

Mutual conductance, impedance and amplification factor versus grid voltage for the valve connected as a triode, No. 308·222.

4.0 Typical Operation:

4.1 PENTODE CONNECTED (g_3 connected to cathode):

Heater Voltage	6·3	6·3	volts
Anode Voltage	100	250	volts
Screen Voltage	100	100	volts
Grid Voltage	—3	—3	volts
Cathode Bias Resistor	1100	1100	ohms
Anode Current	2·0	2·1	mA
Screen Current	0·7	0·6	mA
Anode Impedance	1·5	2·4	MΩ
Mutual Conductance	1·1	1·25	mA/V
Inner Amplification Factor	20	20	
Grid Voltage for 1/100 g_m at V_{g1} = —3	—8	—9	volts

4.2 TRIODE CONNECTED (g_2 connected to anode, g_3 connected to cathode):

Heater Voltage	6·3	volts
Anode Voltage	250	volts
Grid Voltage	—8	volts
Anode Current	6·5	mA
Mutual Conductance	1·72	mA/V
Anode Impedance	11600	ohms
Amplification Factor	20	

5.0 Operation as a Resistance Capacity Coupled AF Amplifier:

5.1 PENTODE CONNECTED: In the table below are given typical operating conditions under various conditions of anode load and supply voltage which yield an output with approximately 5% distortion.

Anode Supply Voltage		100			300		volts
Anode Load Resistor	100	220	470	100	220	470	kΩ
Cathode Bias Resistor	1·3	3·3	5·6	0·56	1·5	2·2	kΩ
Series Screen Resistor	0·47	1·5	2·8	0·47	1·5	2·8	MΩ
Succeeding Stage Grid Resistor	1·0	1·0	1·0	1·0	1·0	1·0	MΩ
Peak Output Voltage	21	28	31	70	92	100	volts
Voltage Gain	65	80	140	104	124	185	volts

Included in this report are curves of anode and screen current versus control grid voltage taken with a supply voltage of 250 volts and various values of anode load resistor. The characteristics for an anode load of 100 kΩ are given on No. 308·225, for 220 kΩ on No. 308·224 and for 470 kΩ on No. 308·223. The method of using these curves for calculating the resistance capacity coupled amplifier performance is as follows:

As an example, assume it is desired to operate with a load resistor of 220 kΩ and a succeeding valve grid leak of 1 MΩ. It can be seen from the curve that control grid current sets in at about —0·5 volts, so that the bias should be chosen to prevent excursion into voltages lower than this. If a value of —2·0 volts is selected, a reasonably linear I_a/V_{g1} characteristic is obtained with the screen grid operating at 50 volts. With such an operating point the anode current is 0·48 mA, and the screen current 0·23 mA. The cathode bias resistor will be $\frac{2 \cdot 0 \times 1000}{0 \cdot 48 + 0 \cdot 23}$ or 2800 ohms. The series screen resistor will be $\frac{200 \times 1000}{0 \cdot 23}$ or 0·87 MΩ.

Allowing a peak input voltage of 0·3 volt, the grid will swing from —2·3 to —1·7 volts, giving an anode current swing of 0·32 mA to 0·68 mA, or 0·36 mA peak to peak. In a 220 kΩ load this corresponds to an output voltage of 79 volts peak to peak or 39·5 volts peak. The voltage gain is then 131 times.

As allowance must be made for the following grid leak of 1 MΩ, these figures must be reduced by a factor of $\frac{10^6}{10^6 + 0 \cdot 22 \times 10^6}$ or 0·82. The stage gain is then 108 times and the output voltage 32·5 volts peak.

The distortion may be estimated by inspection of the relative stage gains at the positive and negative peaks of the signal. The gain at —2·3 volts is

$$\frac{(0 \cdot 48 - 0 \cdot 32) \times 220 \times 0 \cdot 82}{0 \cdot 3} \text{ or } 96 \cdot 5 \text{ times.}$$

The gain at —1·7 volts is $\frac{(0 \cdot 68 - 0 \cdot 48) \times 220 \times 0 \cdot 82}{0 \cdot 3}$ of 120 times.

The distortion is then

$$\frac{120 - \left(\frac{120 + 96 \cdot 5}{2}\right)}{120 + 96 \cdot 5} \times 100 = 5 \cdot 3\%.$$

5.2 TRIODE CONNECTED: The valve may be used as a low μ triode resistance capacity coupled amplifier where the requirements for low hum and noise outweigh these for high gain. In the table below are given typical operating conditions under various conditions of anode load and supply voltage which yield an output with approximately 5% distortion.

Anode Voltage		100			300		volts
Anode Load Resistance	100	220	470	100	220	470	kΩ
Cathode Bias Resistor	7·5	14·5	20·0	6·0	14·0	18·6	kΩ
Succeeding Stage Grid Resistor	0·5	1·0	1·0	0·5	1·0	1·0	MΩ
Peak Output Voltage	22	26	28	88	96	105	volts
Stage Gain	12	13	14	13	14	14	times

A curve, No. 308·226, is included in the report, which shows the relation between the various valve parameters and control grid voltage under conditions of RC coupled operation with various values of anode load resistance.

The method of using this curve for calculating performance is as follows. If it is desired to use an anode load of 220 kΩ with a supply of 250 volts, inspection of the curves indicates a reasonably linear portion over the region of grid voltage —2 to —8 volts. Assuming an operating point at —5 volts the anode impedance and amplification factor are shown as 27·2 kΩ and 17 respectively. The anode load is effectively in parallel with the following valve grid leak, and if this is 1 MΩ the effective load is

$$\frac{220 \times 1000}{1220} \text{ or } 180 \text{ k}\Omega.$$

The stage gain is then $\dfrac{\mu R_a}{R_a + r_a} = \dfrac{17 \times 180}{207 \cdot 2}$ or 14 times.

The distortion may be estimated in the same way as for pentode operation by calculating the stage gain at the extremes of the input signal.

6.0 Low Hum Applications:

6.1 PENTODE CONNECTED: Due to the extensive internal screening very little magnetic and electrostatic hum pick-up occur in the electrode structure. The single ended construction, however, admits the introduction of hum voltages through the capacity and leakage between control grid and heater-leads in the glass button base and valve holder. The hum pick-up due to this will be dependent on the relative values of grid/cathode circuit impedance and stray impedance between grid and heater. The base leakage, and to some extent the capacity, will be subject to considerable variation from valve to valve due to small impurities in, and oxide films on, the surface of the glass. Assuming one side of the heater is earthed, the peak voltage will be approximately 9 volts between grid and the other side of the heater. If a grid circuit impedance of 100 kΩ is assumed, it will be seen that an effective impedance of 10^{11} ohms between grid and heater will introduce nearly 10μV of hum into the grid circuit.

A curve is given, No. 308·231, which shows the maximum hum level referred to the grid plotted against the percentage of valves giving this level, or less, with a grid circuit impedance of 100 kΩ. From this curve it can be estimated how many samples from a large batch will have a hum level below a certain value. It will be seen that to expect a hum level not greater than 50μV would be reasonable, as 90% of the valves would be better than this, but that a requirement for 5μV would give only a 5% yield.

In order to achieve low hum levels from the valve in early stages of an amplifier, precautions must be taken to see that the valve is not situated in any AC fields from chokes, transformers or heater wiring. Similar precautions must obviously be taken with the input wiring, and decoupling earth returns pertaining to the stage should be returned to a single point and not distributed around the chassis forming closed loops liable to couple with AC magnetic fields.

An external screen is not normally necessary for this valve unless it is subject to severe external magnetic fields. A small improvement may be observed if a valve holder with a screening skirt is used, as it provides additional screening where the grid pin enters the base of the valve. A valve holder with low leakage and capacity should be used, and where one side of the heater is earthed, pin 4 should be used for this purpose, so that the live heater pin is remote from the control grid. The cathode by-pass condenser should have as high a capacity as possible to reduce the introduction of hum into the cathode circuit by way of heater-cathode capacity and leakage.

A considerable reduction in hum level may be achieved by returning the earth, not to one side of the heater, but to the slider of a low resistance potentiometer connected across the heater terminals. By this means some of the hum introduced by valve base leakage and capacity may be balanced out. Curve No. 308·227 shows the maximum hum voltage referred to the grid plotted against percentage of the valves with the control adjusted for minimum hum in each case. 90% of the valves show a hum level lower than 25μV, and 100% of the valves are better than 40μV.

The figures quoted are with a grid resistor of 100 kΩ. Wherever possible the grid circuit impedance should be limited to this order to obtain the lowest hum level. If a higher impedance is used there is more possibility of electrostatic and leakage pick-up by the grid. In practice, grid resistors up to 5MΩ in value may be used with only a 50% increase in hum level due to internal coupling in the valve.

6.2 TRIODE CONNECTED: The same considerations apply as in Par. 6.1 for pentode connections. The Curve No. 308·229 shows hum level plotted against percentage of valves using a 100 kΩ grid leak with the valve triode connected. A hum balancing resistor across the heater was employed. 90% of the valves have a hum level referred to the grid of less than 15μV, and the distribution is such that over 70% of the valves can be expected to be better than 5μV. This, for a miniature valve with single ended construction, is about the lowest limit which can be expected from a mass produced valve.

Both pentode and triode hum figures are for a typical RC coupled amplifier using an anode load of 100 kΩ or more, and operating the valve with an anode current of less than 1 mA. If the valve is operated into a choke or transformer load, the anode current should be held below 1·5 mA if a low level of hum is important.

7.0 Microphony: It is not possible to specify the microphony level because this is so much dependent on the circumstances of the application. The valve has been designed with a very rigid structure to minimise the effect of vibration, but there will always be some movement of individual grid wires when vibrated at their resonant frequency. By careful design, all low frequency resonances due to loose electrodes have been removed, so that there are no internal resonances below 1000 c/s. This is shown on the Curves No. 308·232 and 308·233, which indicate the amplitude of the resonances when the valve is vibrated across the major and minor axes respectively. The frequency of vibration was varied from 10 to 3000 c/s with a constant acceleration of 2·5g.

It is interesting to note that the amplitude of vibration to produce an acceleration of 2·5g varies from 0·25 in. at 10 c/s to approximately 0·001 in. at 150 c/s, while at 5000 c/s the peak amplitude is only 2 millionths of an inch. Most of the higher frequency vibrations are heavily damped by the chassis and valve holder mounting. The use of an anti-microphonic type of valve holder usually eliminates vibration effects at these frequencies.

Where the valve is being used at the limit of its sensitivity it is important to minimise as far as possible by flexible valve holder mountings all mechanical and acoustical vibrations. This is particularly important where the valve is included in the same cabinet as the loudspeaker, or a motor such as in magnetic tape recorders and sound film projectors.

8.0 Valve Shot noise (Hiss): A certain amount of random noise will be generated in the valve by the random arrival of electrons at the anode, and this is further increased by the partition of the cathode current between anode and screen, as the random collection of electrons by the screen must have its effect as an increased variation in the number of electrons arriving at the anode. This is inherent in the valve and cannot be entirely eliminated. A major contribution to valve noise, however, is noise produced by leakage between electrodes over the mica insulators and in the base. Also a poorly activated cathode can produce a noise voltage swamping the normal valve noise.

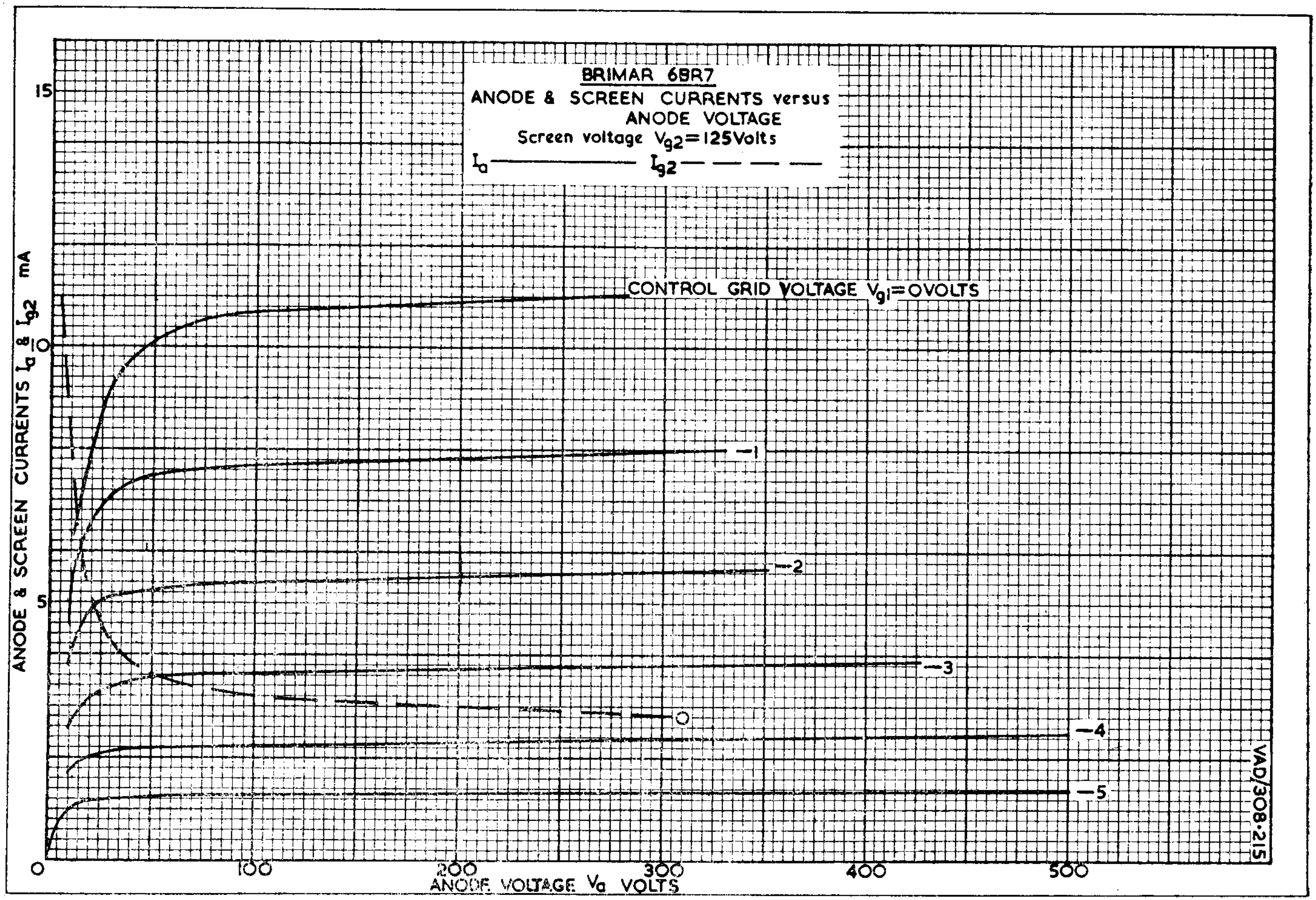
The shot noise in the 6BR7 has been reduced to a minimum by careful design, and the noise due to leakage controlled by careful assembly and inspection. A certain amount of leakage noise is unavoidable in a mass produced valve, and this reveals itself as a small variation in noise level from valve to valve.

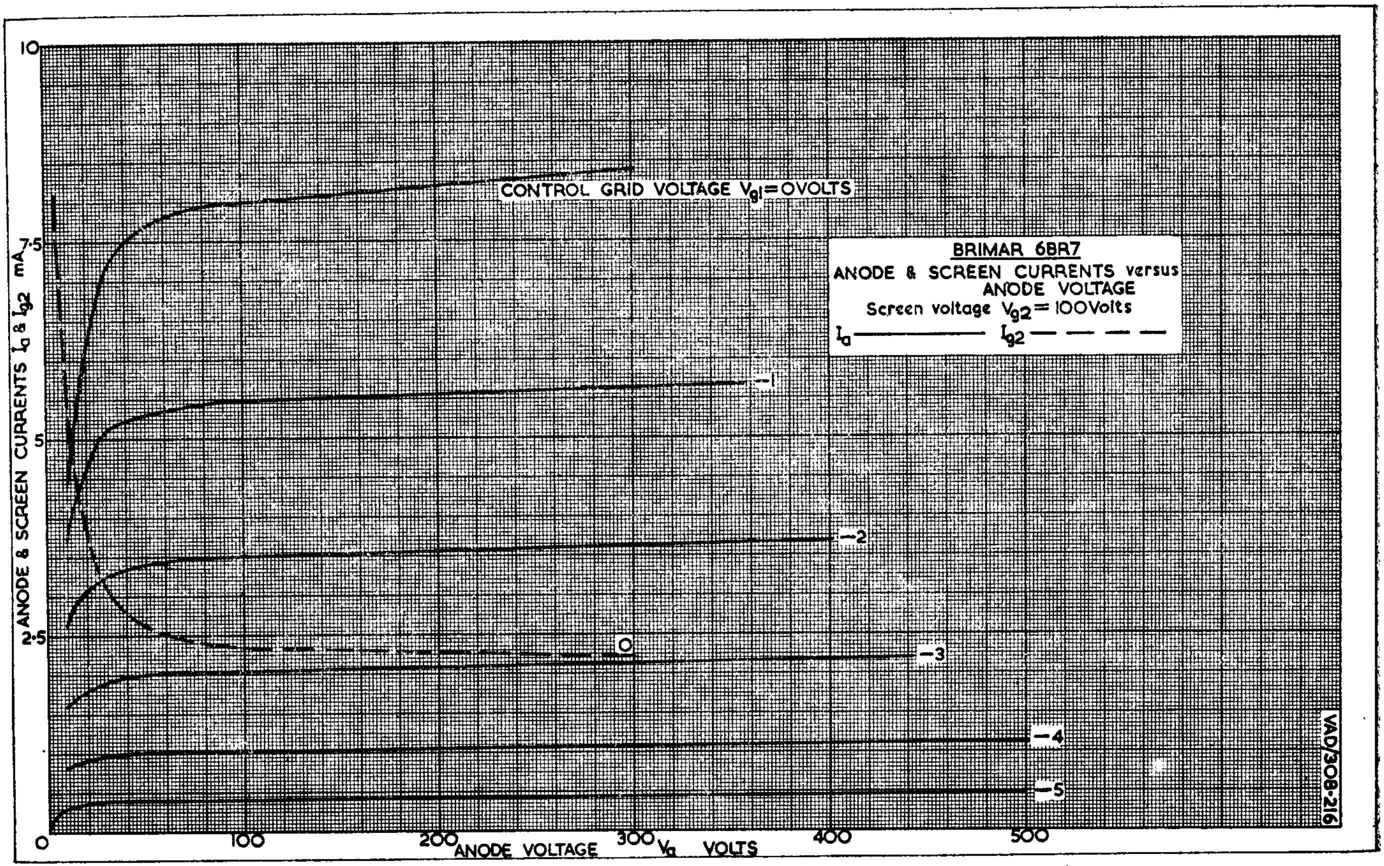
The curve No. 308·228 shows the maximum hiss voltage plotted against the percentage of valves, using a grid resistor of 100 kΩ and a bandwidth of 10 kc/s. The curve is very steep and indicates that a hiss level on the grid always lower than 7μV is to be expected.

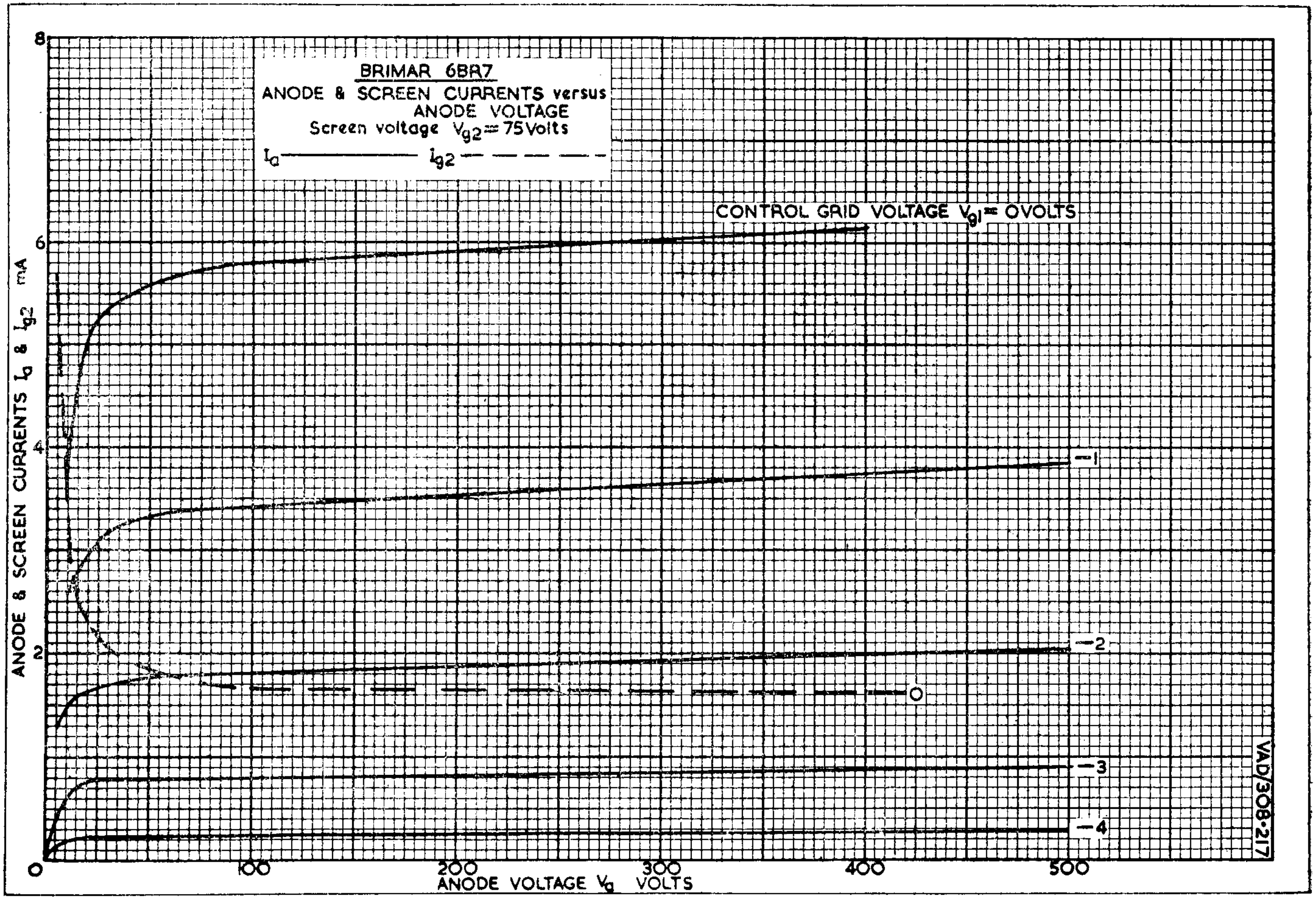
The Curve No. 308·230 shows the same parameters with the valve triode connected. Here partition noise has been eliminated. As would be expected the higher noise levels are unaltered because they are due mainly to leakage which is not greatly affected by whether the valve is triode or pentode connected. The lower noise level is reduced, and in fact falls below the thermal agitation noise generated by the 100 kΩ grid resistor, which in a 10 kc/s bandwidth at 20° C is about 4μV.

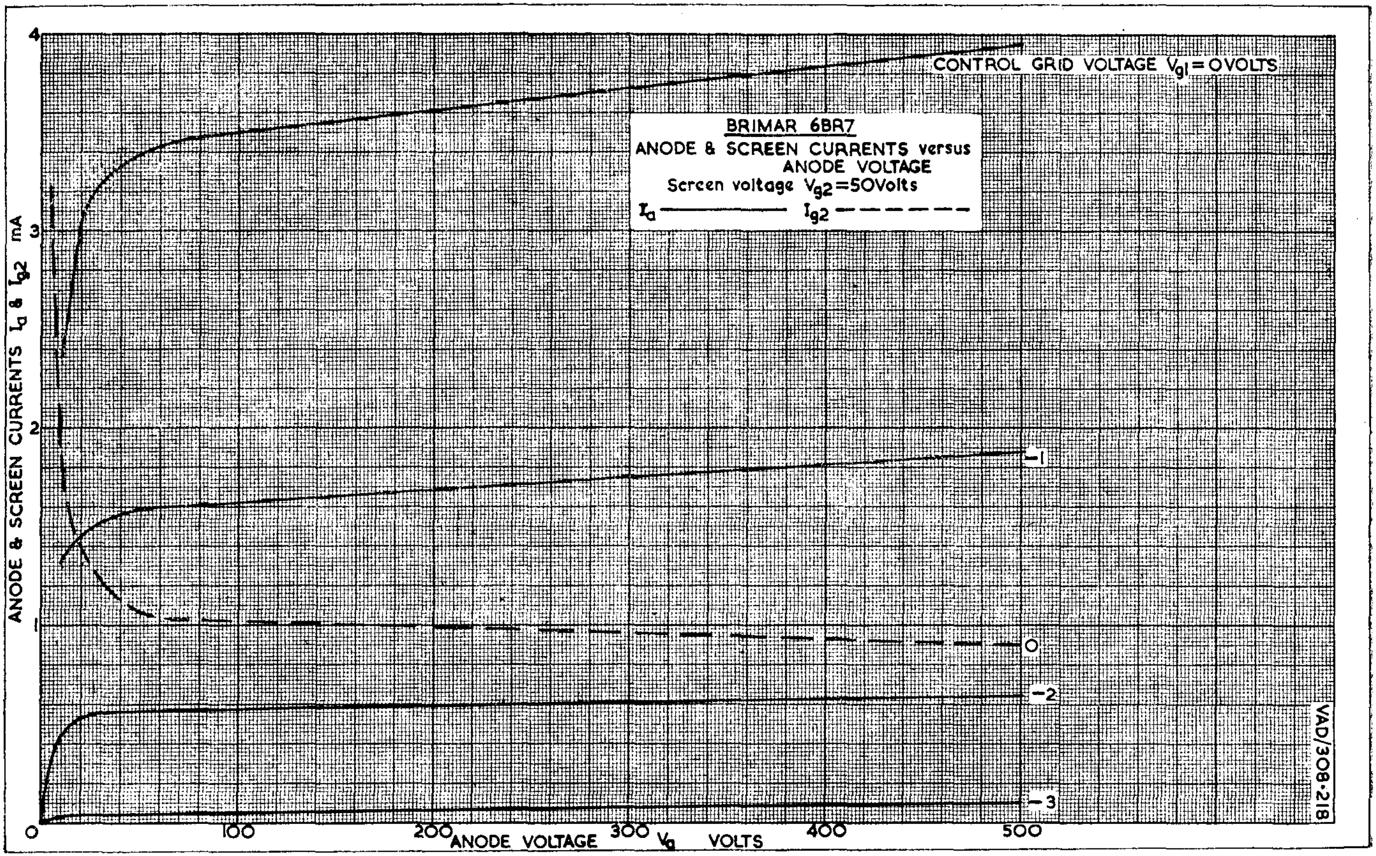
9.0 Conclusions: While it is not claimed that the 6BR7 has exceptionally low noise properties, it can be stated that it is a very great improvement over average normal valves. Individual samples taken at random from a large batch can be expected to give consistently good performance. As with normal receiving type valves, by selection, it is possible to find individual samples of outstanding performance, but whereas with normal types the average product is many times inferior to the selected samples in the case of the 6BR7 the average product is little different from the best samples selected.

In spite of this, care must be taken when designing prototype equipment for high gain, low noise applications, to ensure that the design is not finalised from the experience acquired from a single sample of the 6BR7.

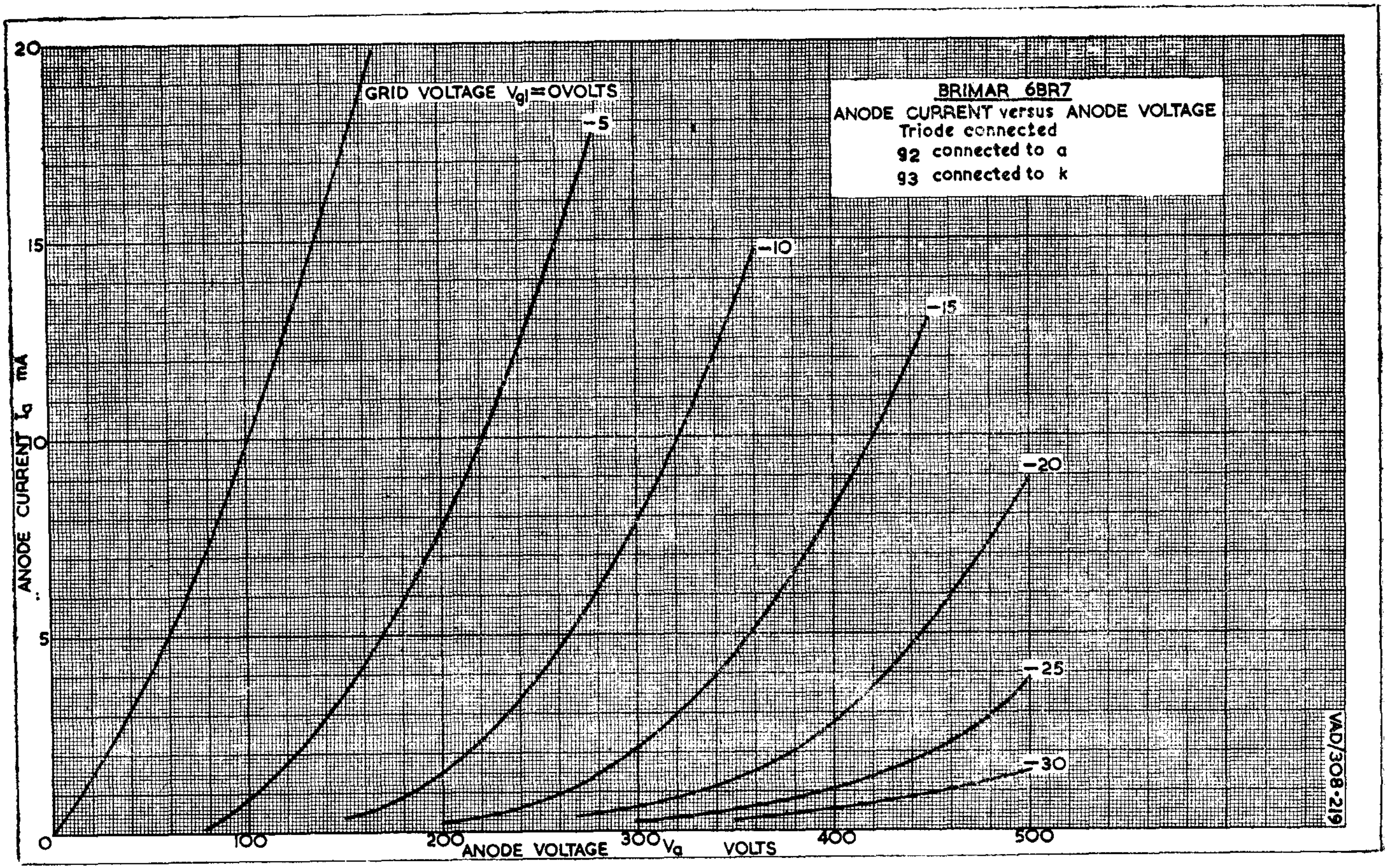

BRIMAR 6BR7
ANODE & SCREEN CURRENTS versus ANODE VOLTAGE
Screen voltage Vg2=125Volts
Ia —— Ig2 – – –
CONTROL GRID VOLTAGE Vg1=0VOLTS
−1
−2
−3
0
−4
−5
15
10
5
0
100
200
300
400
500
ANODE & SCREEN CURRENTS Ia & Ig2 mA
ANODE VOLTAGE Va VOLTS
VAD/308·215


BRIMAR 6BR7
ANODE & SCREEN CURRENTS versus ANODE VOLTAGE
Screen voltage V_{g2} = 100 Volts
I_a ———— I_{g2} – – – –
CONTROL GRID VOLTAGE V_{g1} = 0 VOLTS
−1
−2
0
−3
−4
−5
ANODE & SCREEN CURRENTS I_a & I_{g2} mA
ANODE VOLTAGE V_a VOLTS
0
100
200
300
400
500
2·5
5
7·5
10
VAD/308-216

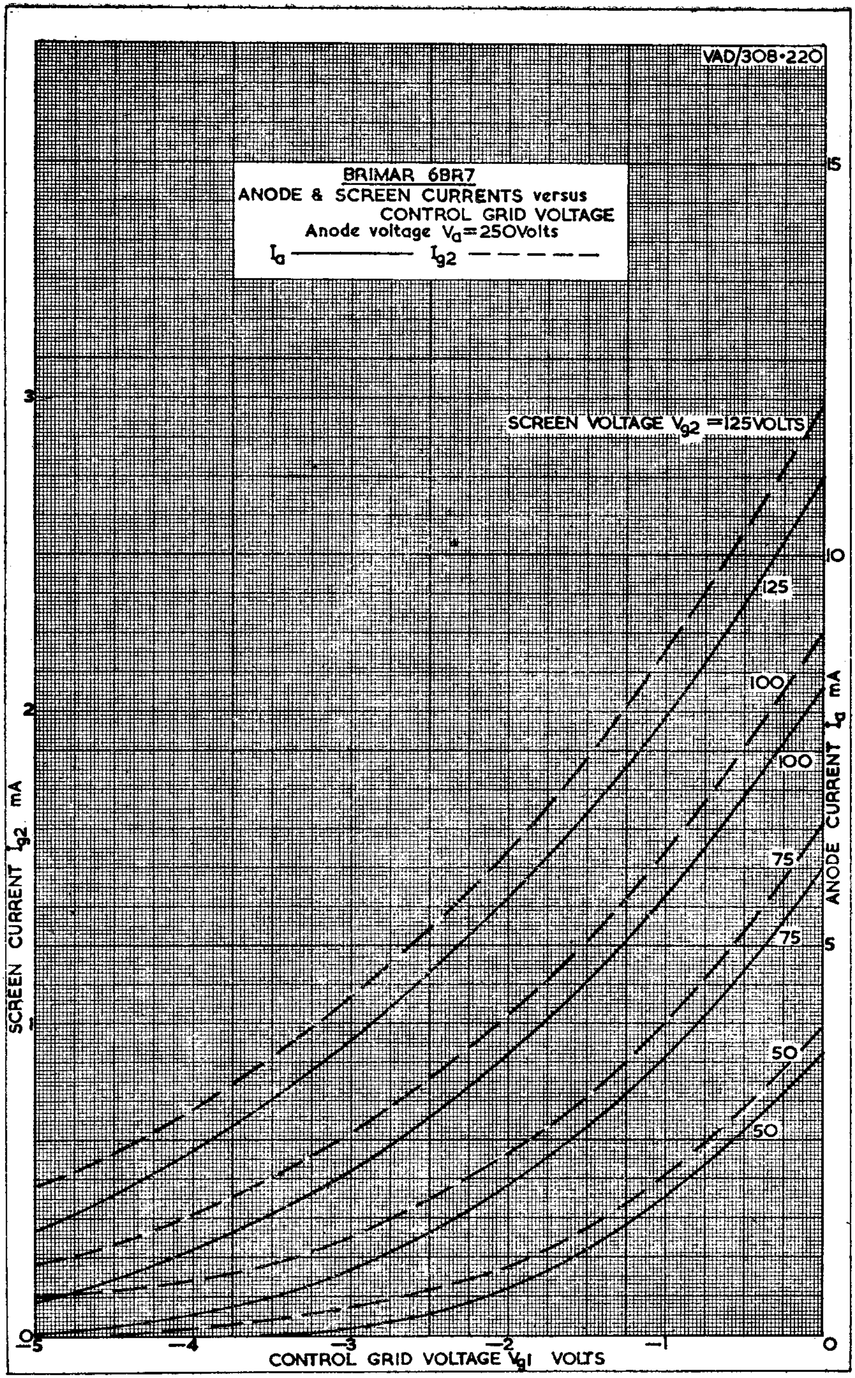

BRIMAR 6BR7
ANODE & SCREEN CURRENTS versus ANODE VOLTAGE
Screen voltage V_{g2} = 75 Volts
I_a ——— I_{g2} — — —
CONTROL GRID VOLTAGE V_{g1} = 0 VOLTS
−1
−2
0
−3
−4
ANODE & SCREEN CURRENTS I_a & I_{g2} mA
ANODE VOLTAGE V_a VOLTS
0
2
4
6
8
100
200
300
400
500
VAD/308·217



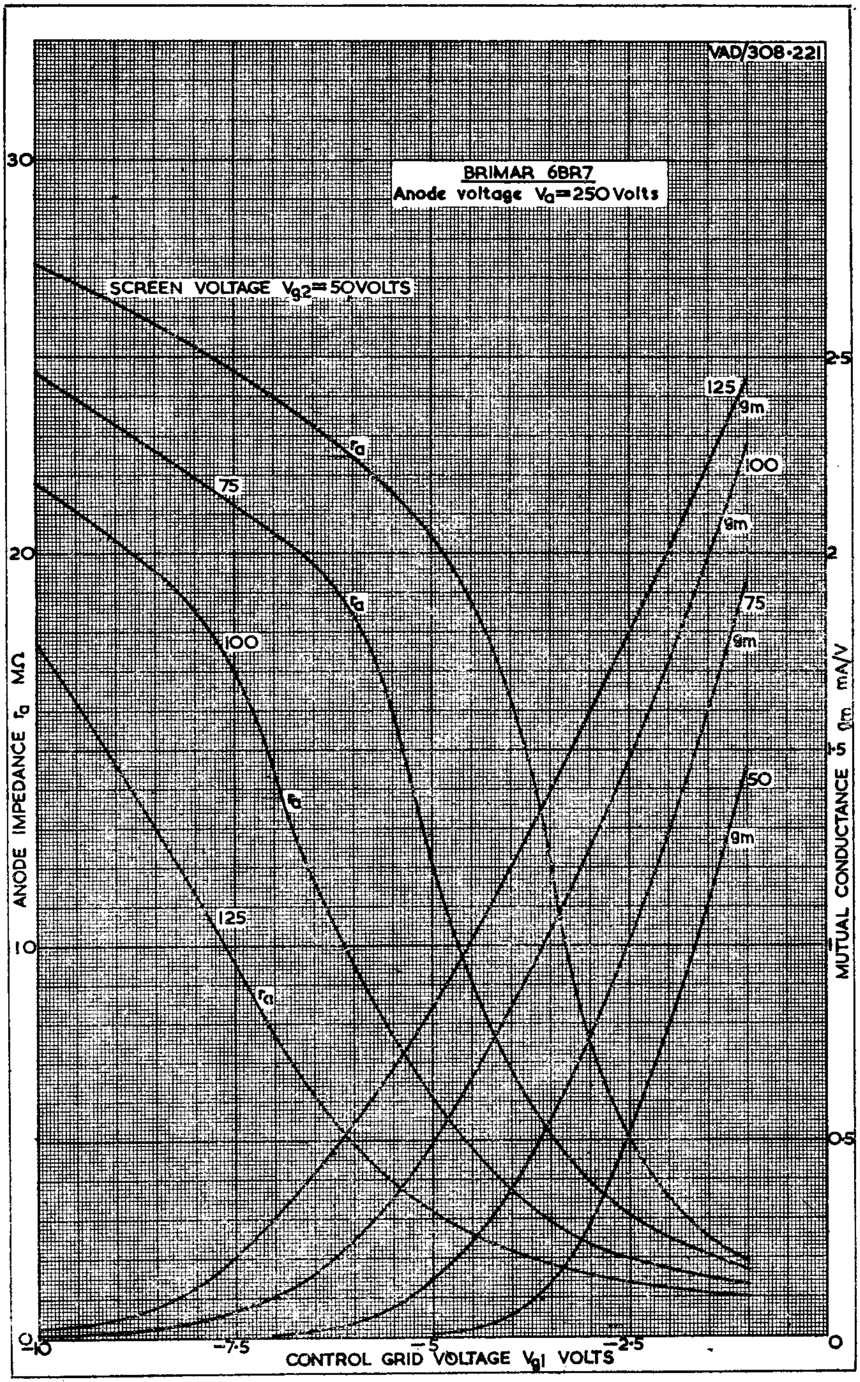
BRIMAR 6BR7
ANODE & SCREEN CURRENTS versus ANODE VOLTAGE
Screen voltage V_{g2}=50Volts
I_a ——— I_{g2} - - - -
CONTROL GRID VOLTAGE V_{g1}=0VOLTS
−1
0
−2
−3
ANODE & SCREEN CURRENTS I_a & I_{g2} mA
ANODE VOLTAGE V_a VOLTS
0
100
200
300
400
500
1
2
3
4
VAD/308·218



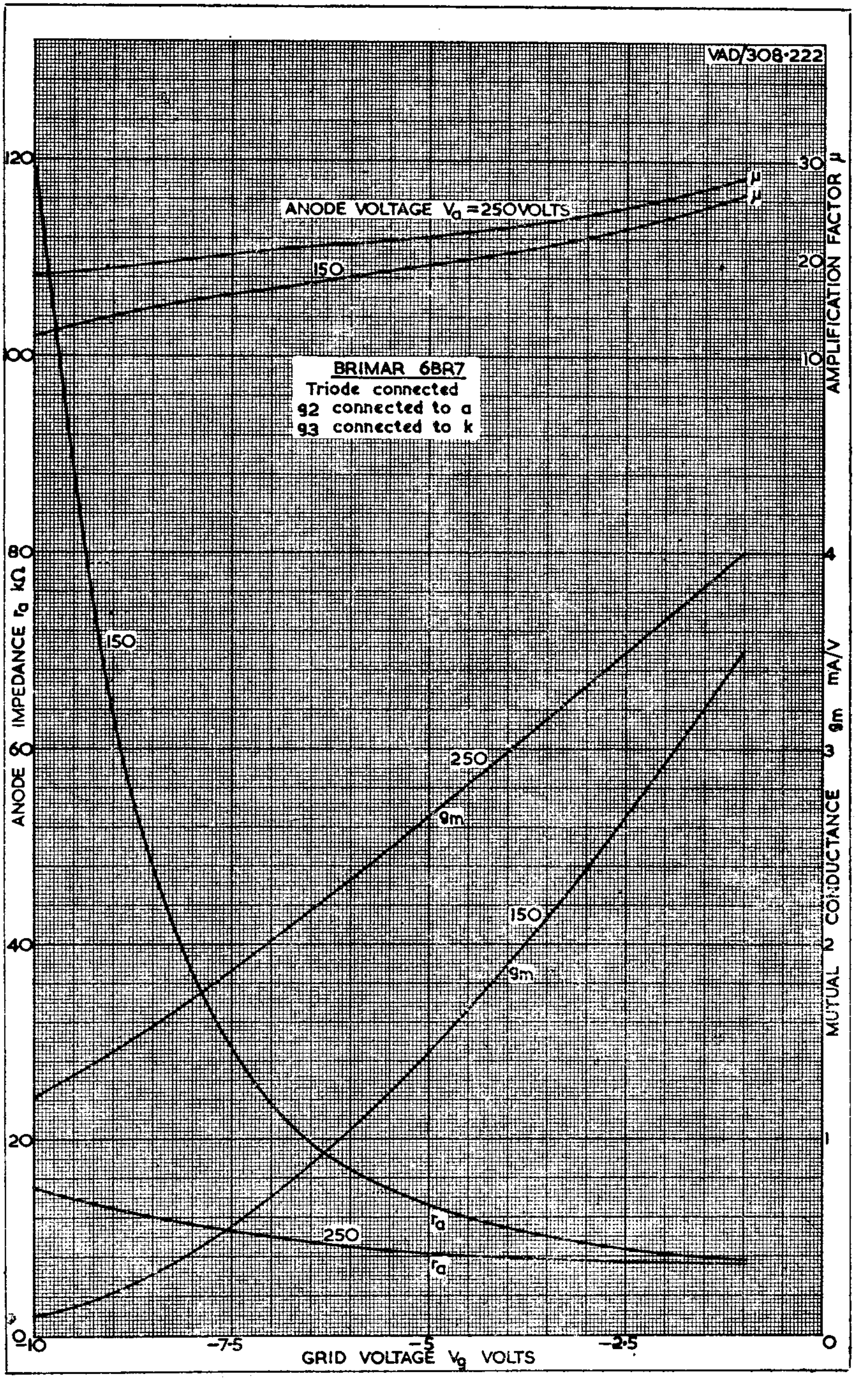
BRIMAR 6BR7
ANODE CURRENT versus ANODE VOLTAGE
Triode connected
g2 connected to a
g3 connected to k
GRID VOLTAGE Vg1=0VOLTS
-5
-10
-15
-20
-25
-30
ANODE CURRENT Ia mA
20
15
10
5
0
100
200
300
400
500
ANODE VOLTAGE Va VOLTS
VAD/308·219

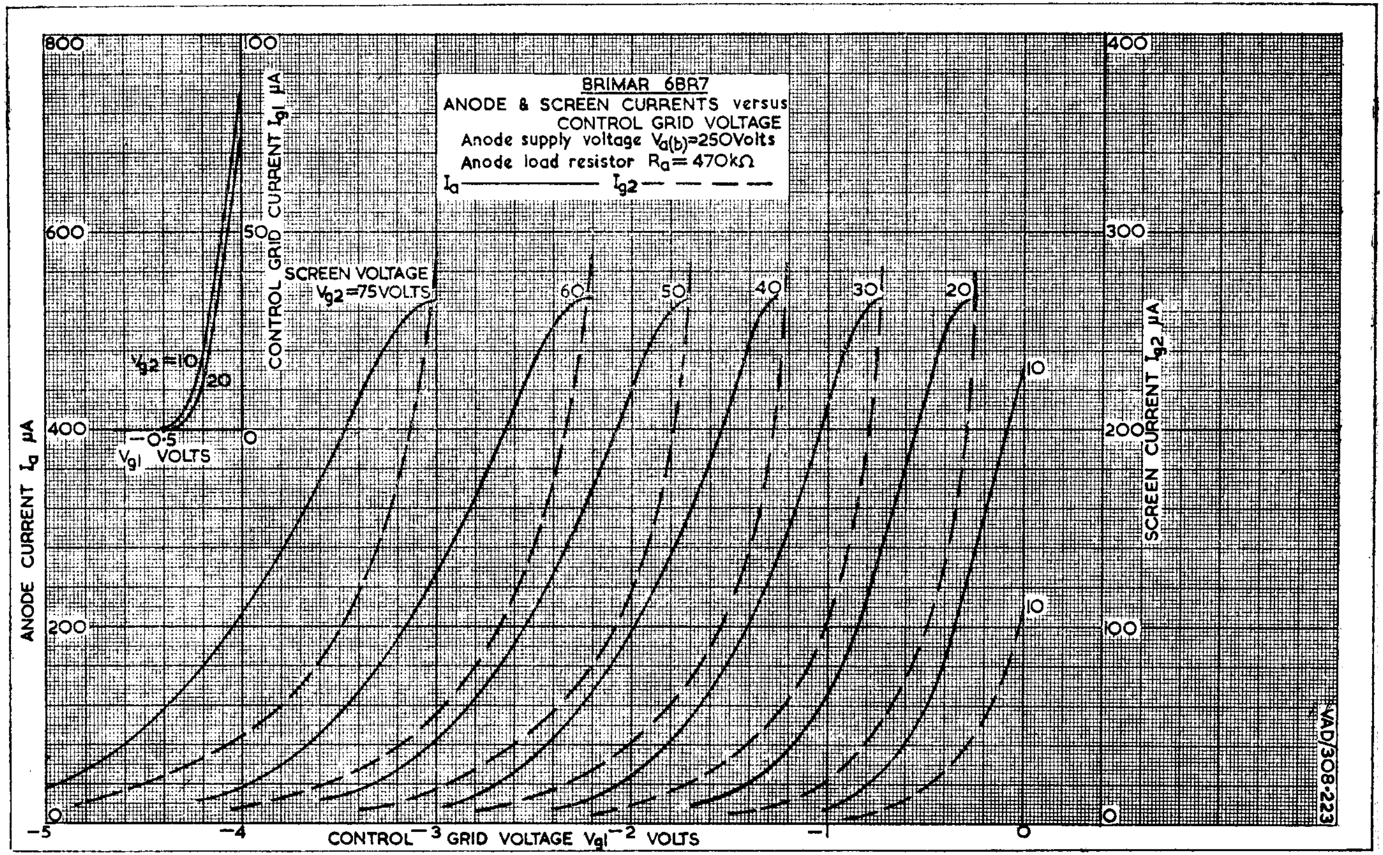


VAD/308·220
BRIMAR 6BR7
ANODE & SCREEN CURRENTS versus CONTROL GRID VOLTAGE
Anode voltage Va=250Volts
Ia ———— Ig2 — — — —
SCREEN VOLTAGE Vg2 =125VOLTS
125
100
100
75
75
50
50
SCREEN CURRENT Ig2 mA
ANODE CURRENT Ia mA
CONTROL GRID VOLTAGE Vg1 VOLTS
3
2
1
0
15
10
5
0
−5
−4
−3
−2
−1
0

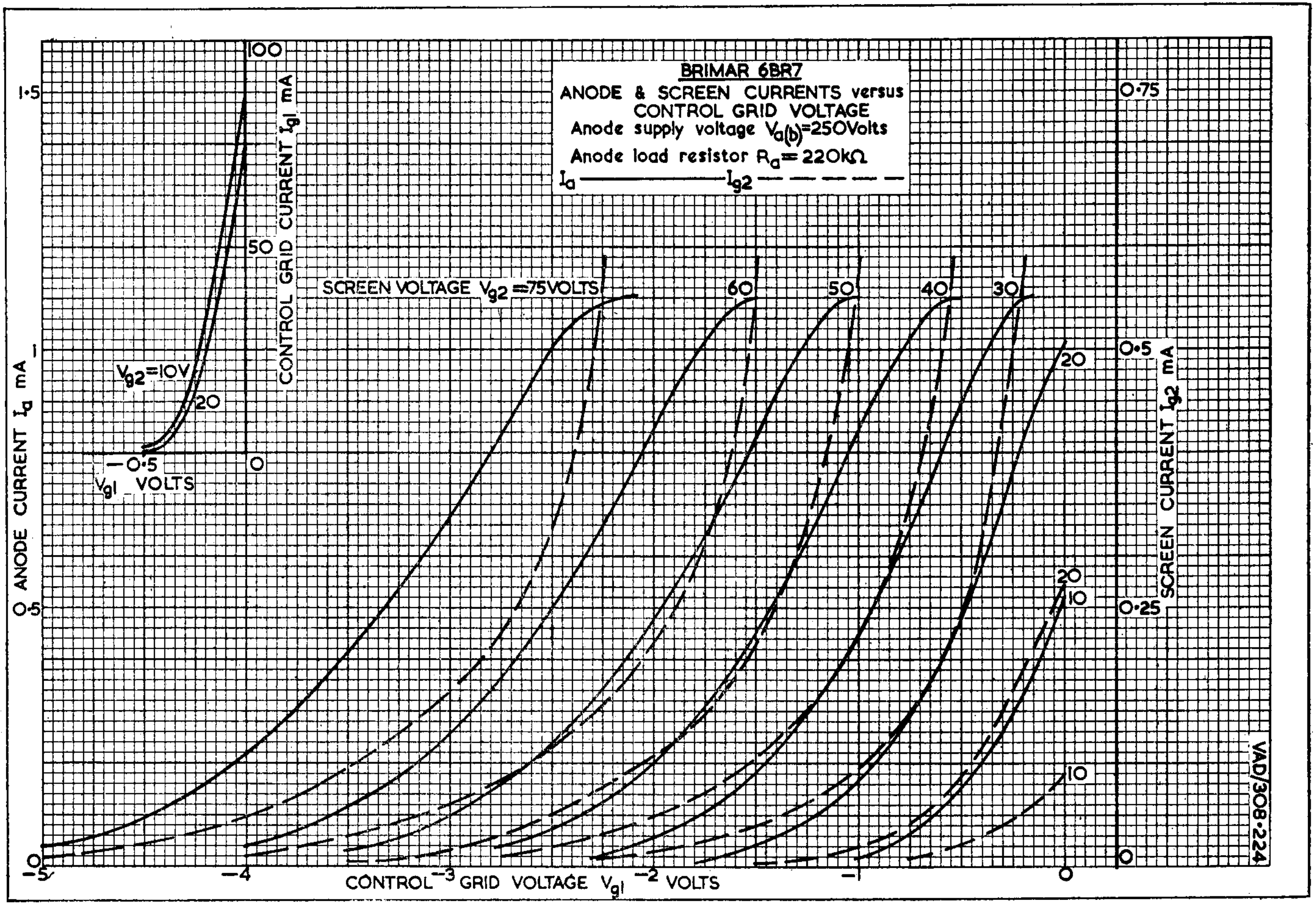


VAD/308·221
BRIMAR 6BR7
Anode voltage Va = 250 Volts
SCREEN VOLTAGE Vg2 = 50 VOLTS
ANODE IMPEDANCE ra MΩ
MUTUAL CONDUCTANCE gm mA/V
CONTROL GRID VOLTAGE Vg1 VOLTS
30
20
10
0
2·5
2
1·5
1
0·5
0
-10
-7·5
-5
-2·5
75
100
125
50
ra
gm

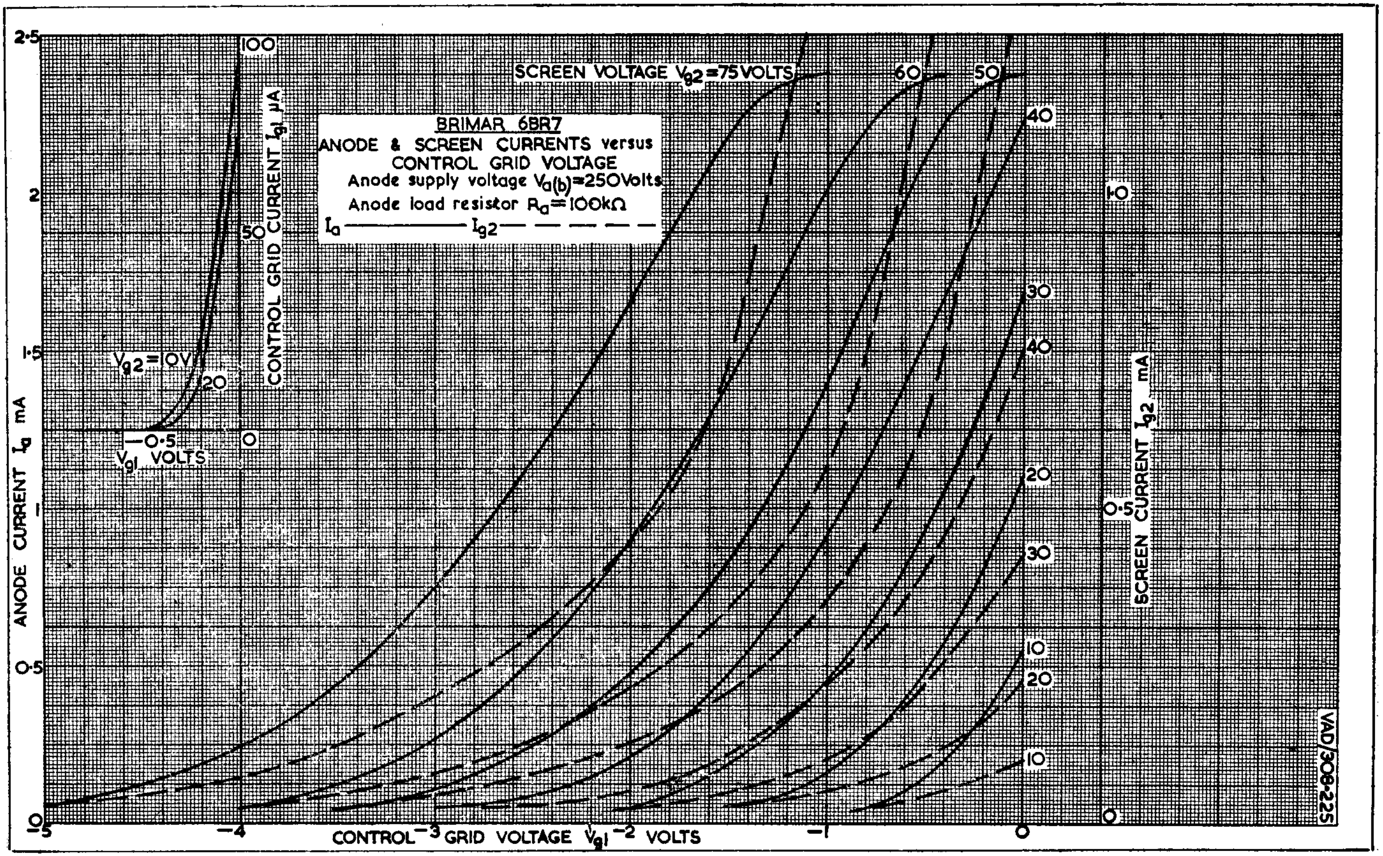

VAD/308·222
ANODE VOLTAGE Va = 250 VOLTS
150
μ
μ
BRIMAR 6BR7
Triode connected
g2 connected to a
g3 connected to k
150
250
gm
150
gm
ra
250
ra
ANODE IMPEDANCE ra kΩ
AMPLIFICATION FACTOR μ
MUTUAL CONDUCTANCE gm mA/V
GRID VOLTAGE Vg VOLTS
120
100
80
60
40
20
0
30
20
10
4
3
2
1
0
-10
-7·5
-5
-2·5

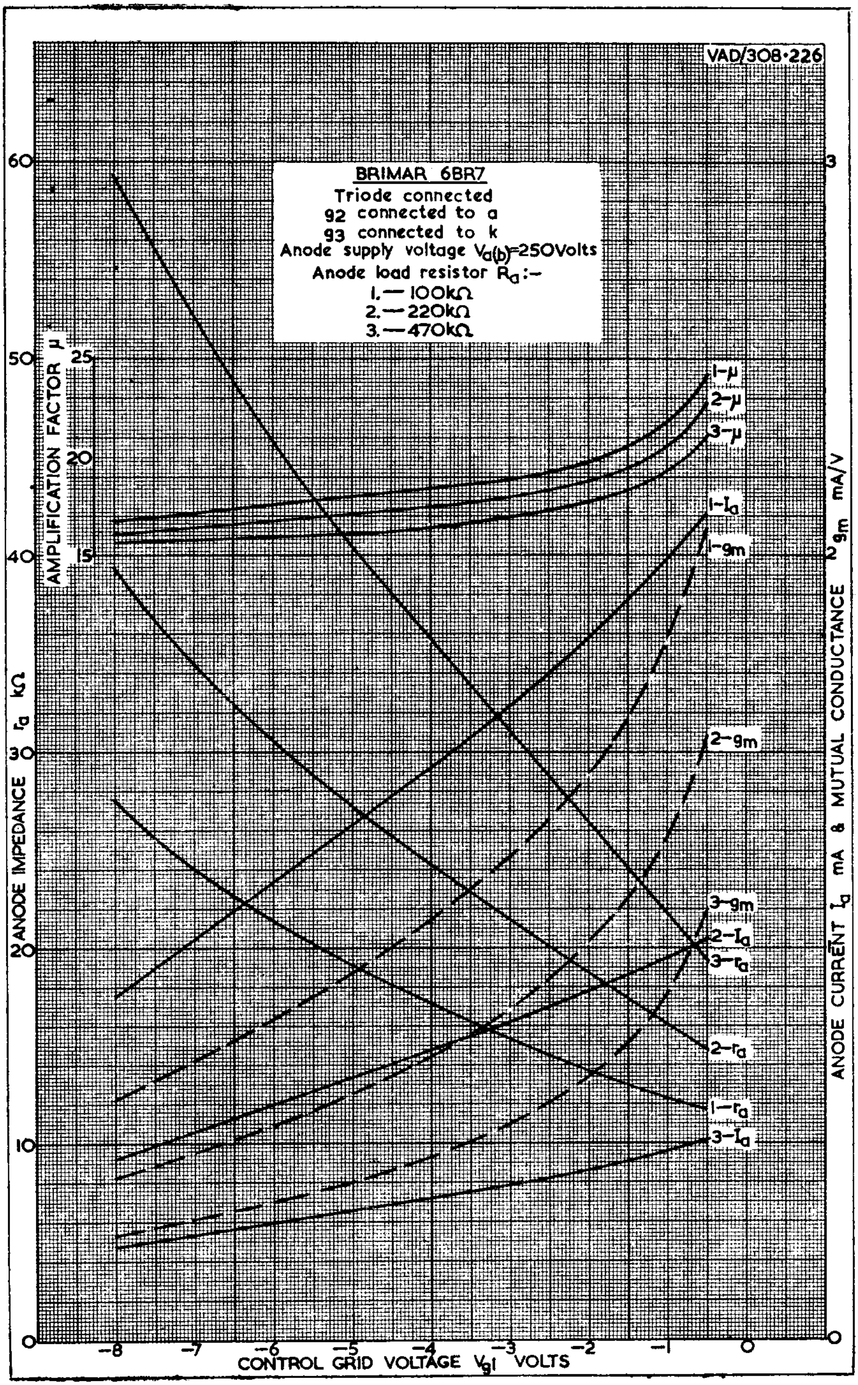


BRIMAR 6BR7
ANODE & SCREEN CURRENTS versus CONTROL GRID VOLTAGE
Anode supply voltage $V_{a(b)}$=250Volts
Anode load resistor R_a= 470kΩ
I_a ——— I_{g2} — — —
SCREEN VOLTAGE V_{g2}=75VOLTS
60
50
40
30
20
10
10
V_{g2}=10
20
CONTROL GRID CURRENT I_{g1} μA
V_{g1} VOLTS
−0·5
ANODE CURRENT I_a μA
SCREEN CURRENT I_{g2} μA
CONTROL GRID VOLTAGE V_{g1} VOLTS
VAD/308-223

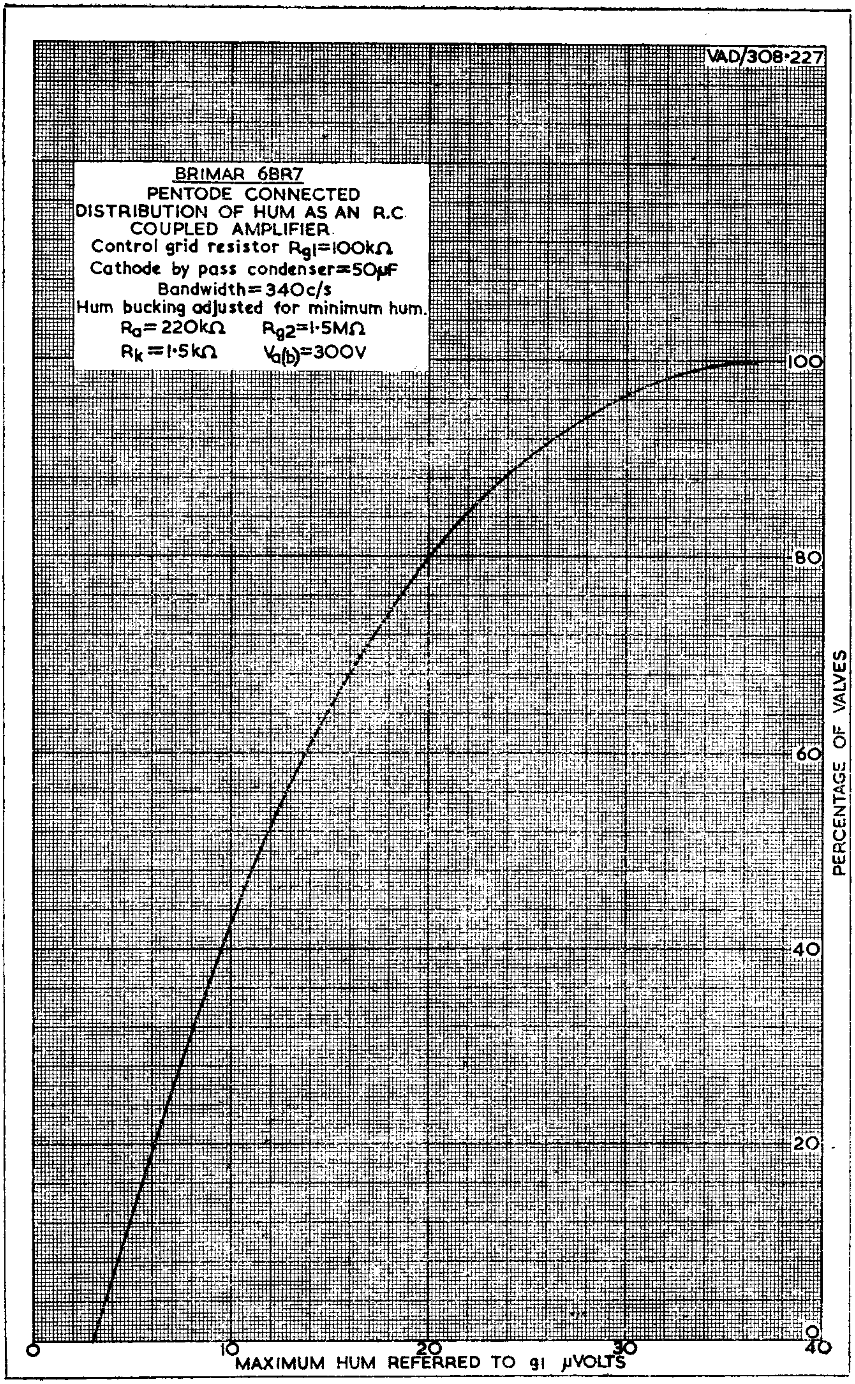


BRIMAR 6BR7
ANODE & SCREEN CURRENTS versus CONTROL GRID VOLTAGE
Anode supply voltage $V_{a(b)}$=250Volts
Anode load resistor R_a=220kΩ
I_a ——— I_{g2} – – – –
SCREEN VOLTAGE V_{g2} =75VOLTS
60
50
40
30
20
10
V_{g2}=10V
CONTROL GRID CURRENT I_{g1} mA
100
50
0
−0·5
V_{g1} VOLTS
ANODE CURRENT I_a mA
1·5
1
0·5
0
SCREEN CURRENT I_{g2} mA
0·75
0·5
0·25
CONTROL GRID VOLTAGE V_{g1} VOLTS
−5
−4
−3
−2
−1
VAD/308·224

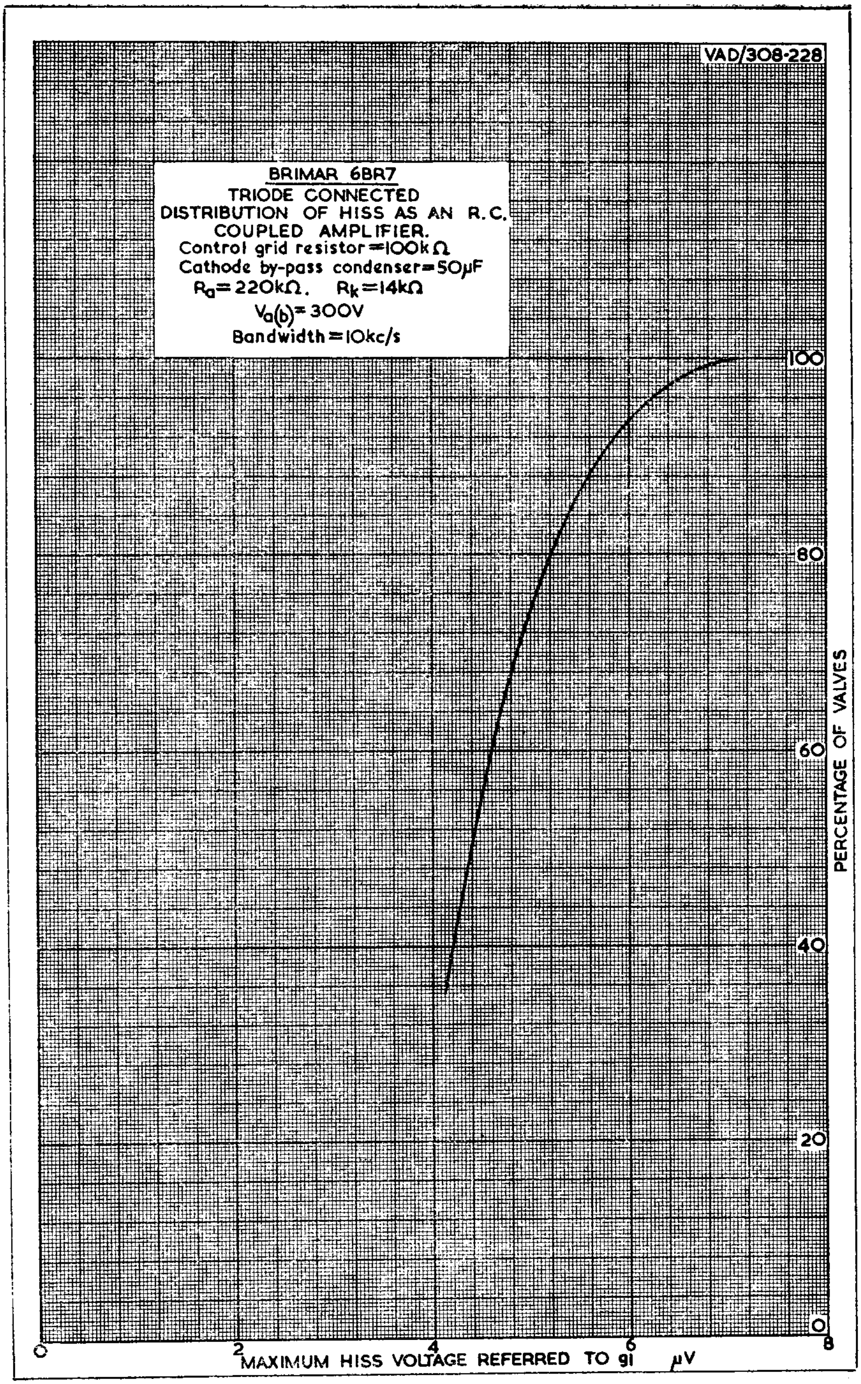

BRIMAR 6BR7
ANODE & SCREEN CURRENTS versus CONTROL GRID VOLTAGE
Anode supply voltage Va(b)=250Volts
Anode load resistor Ra=100kΩ
Ia ——— Ig2 — — —
SCREEN VOLTAGE Vg2=75VOLTS
60
50
40
30
40
20
30
10
20
10
Vg2=10V
20
—0·5
Vg1 VOLTS
100
50
0
CONTROL GRID CURRENT Ig1 μA
SCREEN CURRENT Ig2 mA
1·0
0·5
0
ANODE CURRENT Ia mA
2·5
2
1·5
1
0·5
0
−5
−4
−3
−2
−1
0
CONTROL GRID VOLTAGE Vg1 VOLTS
VAD/308·225

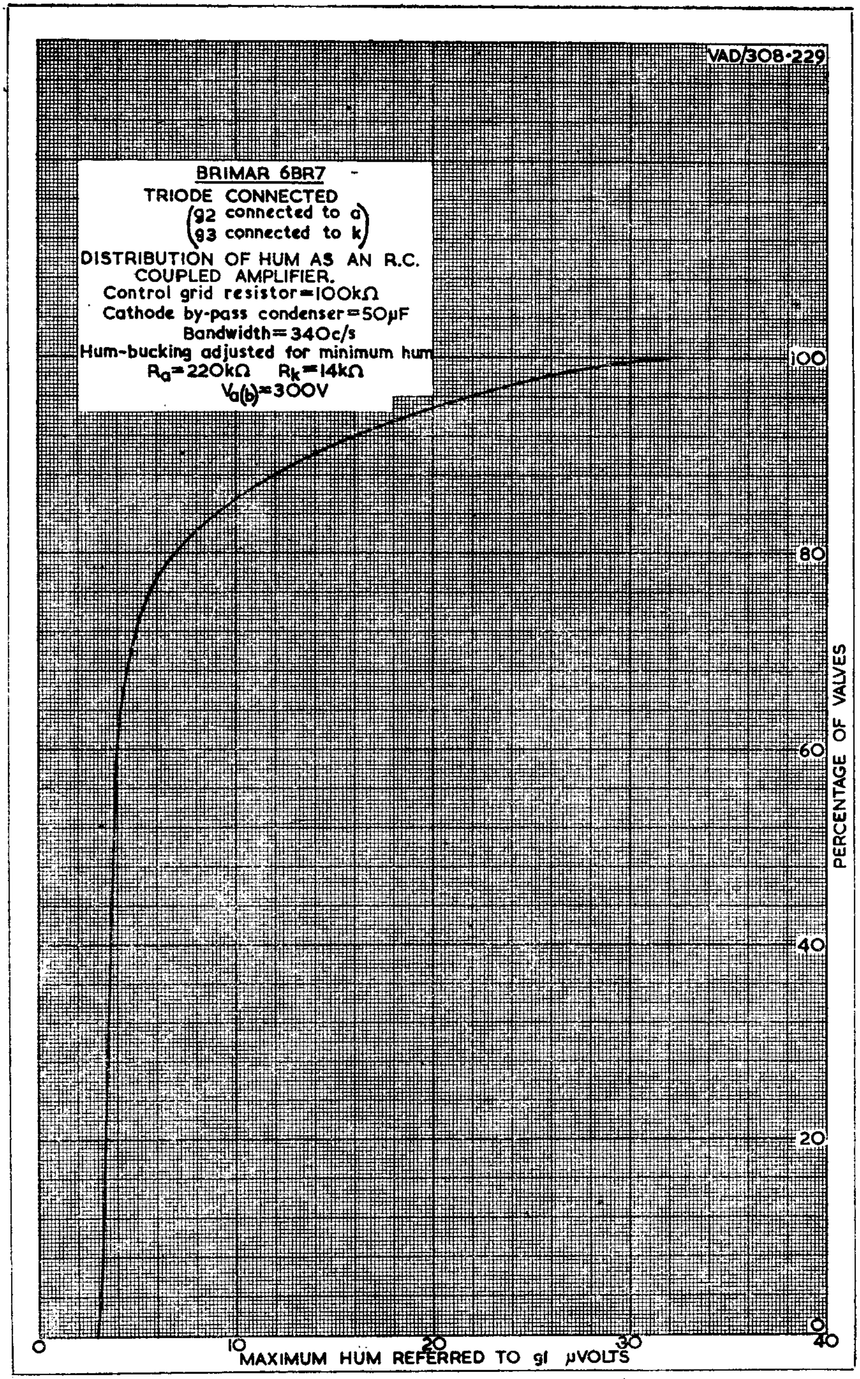


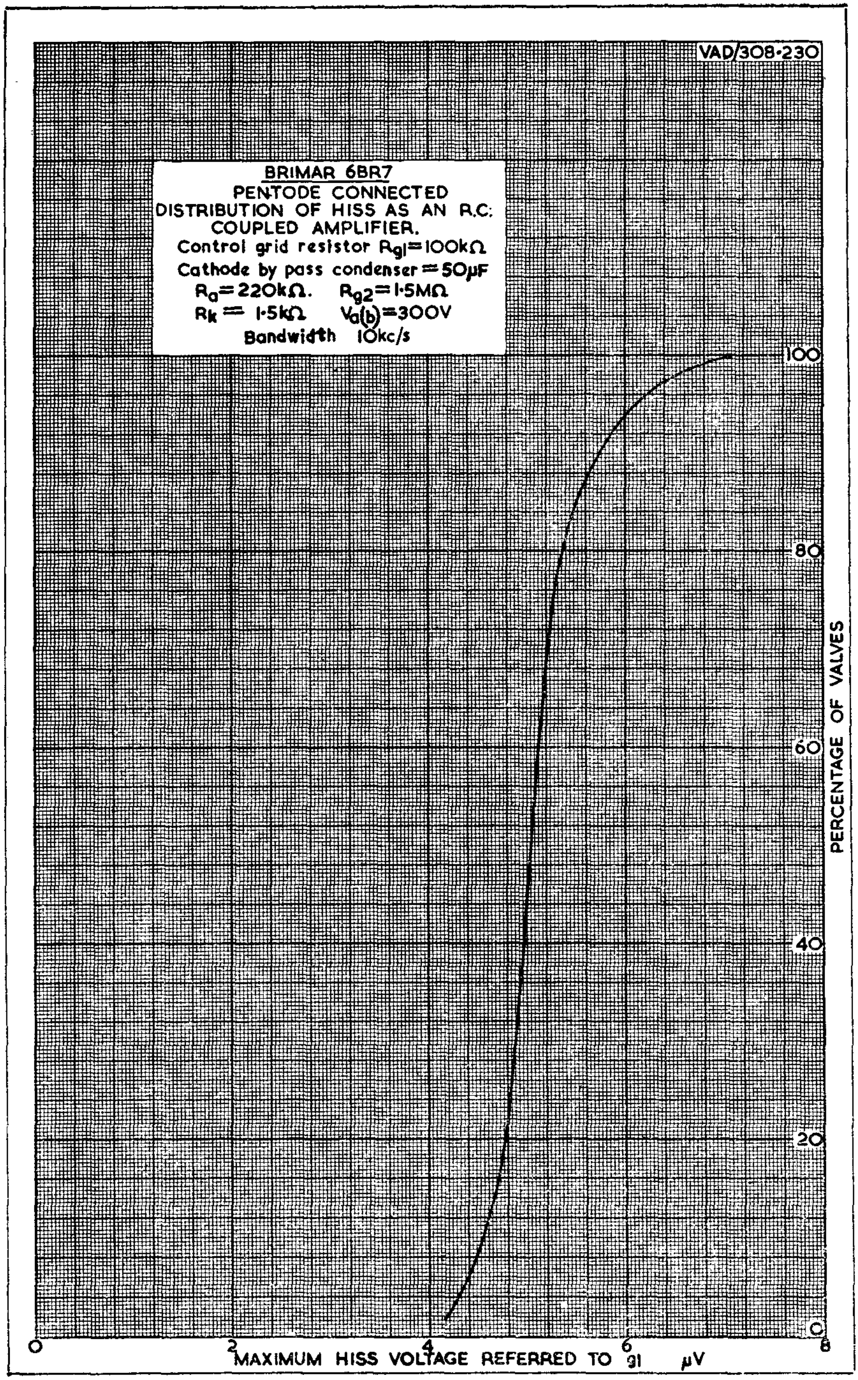
VAD/308·226
BRIMAR 6BR7
Triode connected
g2 connected to a
g3 connected to k
Anode supply voltage Va(b)=250Volts
Anode load resistor Ra:-
1.— 100kΩ
2.— 220kΩ
3.— 470kΩ
AMPLIFICATION FACTOR μ
ANODE IMPEDANCE ra kΩ
ANODE CURRENT Ia mA & MUTUAL CONDUCTANCE gm mA/V
CONTROL GRID VOLTAGE Vg1 VOLTS
1-μ
2-μ
3-μ
1-Ia
1-gm
2-gm
3-gm
2-Ia
3-ra
2-ra
1-ra
3-Ia



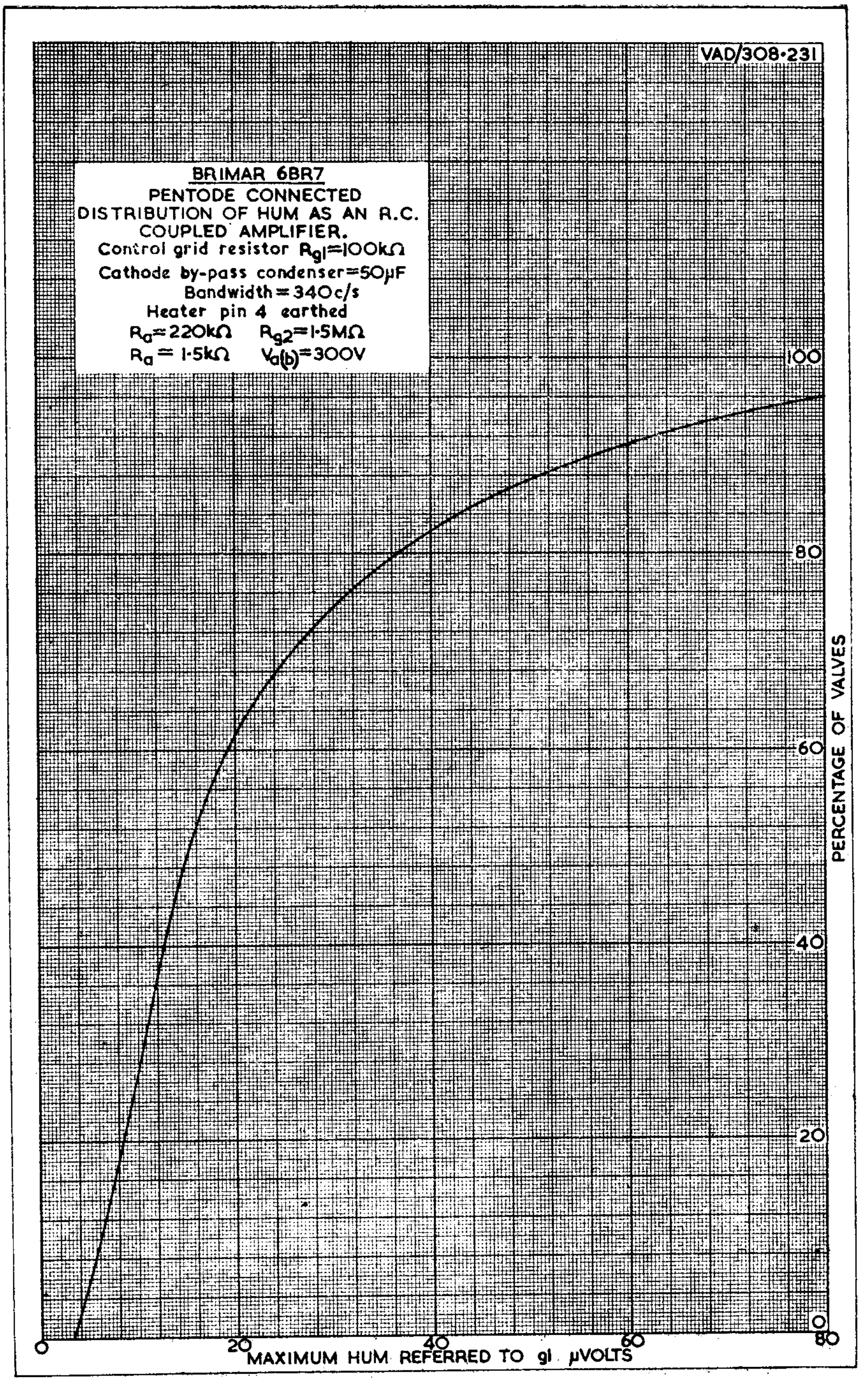
VAD/308·227
BRIMAR 6BR7
PENTODE CONNECTED
DISTRIBUTION OF HUM AS AN R.C.
COUPLED AMPLIFIER
Control grid resistor Rg1=100kΩ
Cathode by pass condenser=50µF
Bandwidth=340c/s
Hum bucking adjusted for minimum hum.
Ra=220kΩ Rg2=1·5MΩ
Rk=1·5kΩ Va(b)=300V
100
80
60
40
20
0
PERCENTAGE OF VALVES
0
10
20
30
40
MAXIMUM HUM REFERRED TO g1 µVOLTS

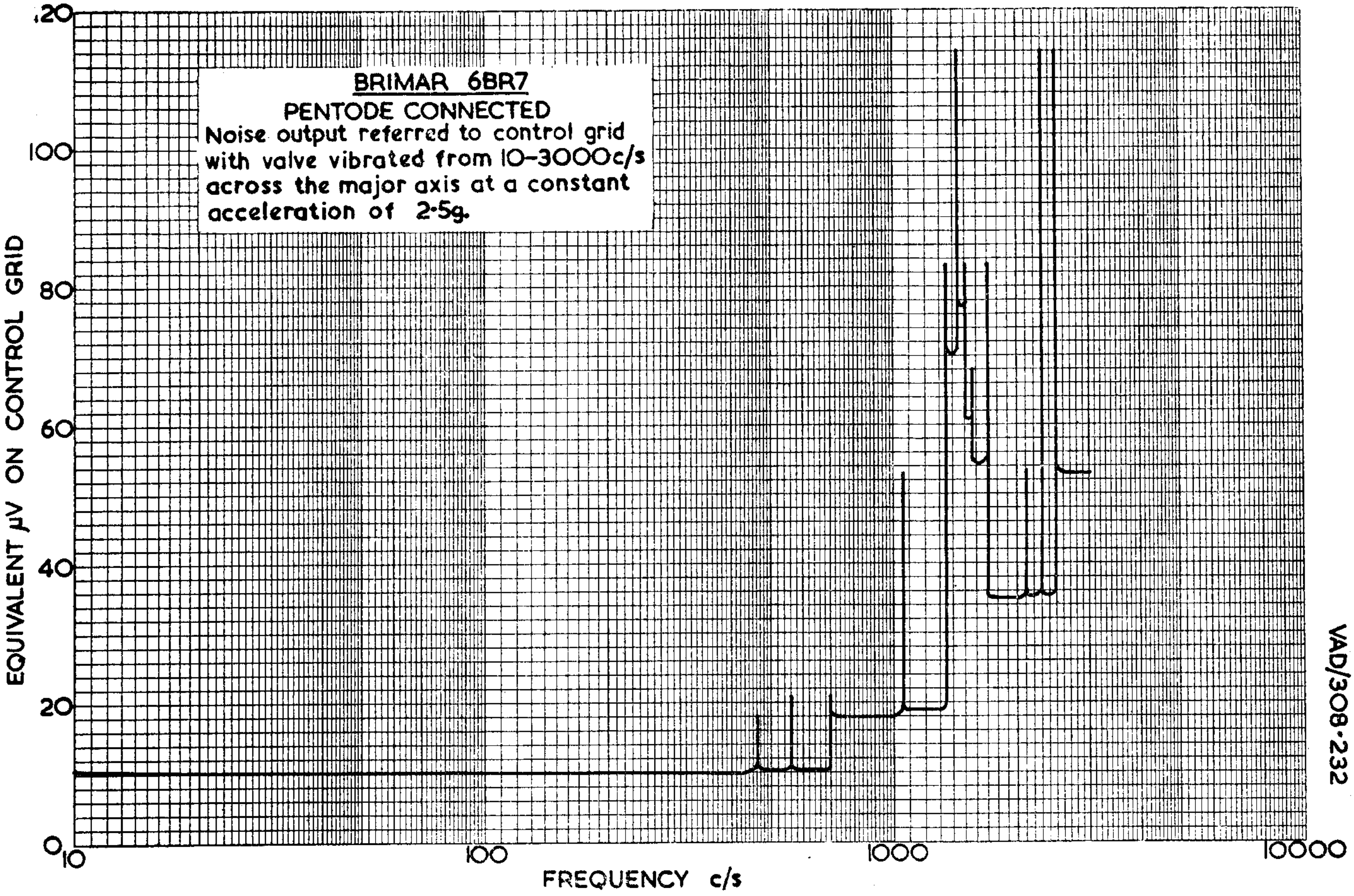

VAD/308-228
BRIMAR 6BR7
TRIODE CONNECTED
DISTRIBUTION OF HISS AS AN R.C. COUPLED AMPLIFIER.
Control grid resistor = 100kΩ
Cathode by-pass condenser = 50μF
R_a = 220kΩ. R_k = 14kΩ
$V_{a(b)}$ = 300V
Bandwidth = 10kc/s
PERCENTAGE OF VALVES
100
80
60
40
20
0
0
2
4
6
8
MAXIMUM HISS VOLTAGE REFERRED TO g1 μV


VAD/308-229
BRIMAR 6BR7
TRIODE CONNECTED
(g2 connected to a)
(g3 connected to k)
DISTRIBUTION OF HUM AS AN R.C. COUPLED AMPLIFIER.
Control grid resistor=100kΩ
Cathode by-pass condenser=50μF
Bandwidth=340c/s
Hum-bucking adjusted for minimum hum
Ra=220kΩ Rk=14kΩ
Va(b)=300V
100
80
60
40
20
0
PERCENTAGE OF VALVES
0
10
20
30
40
MAXIMUM HUM REFERRED TO g1 μVOLTS



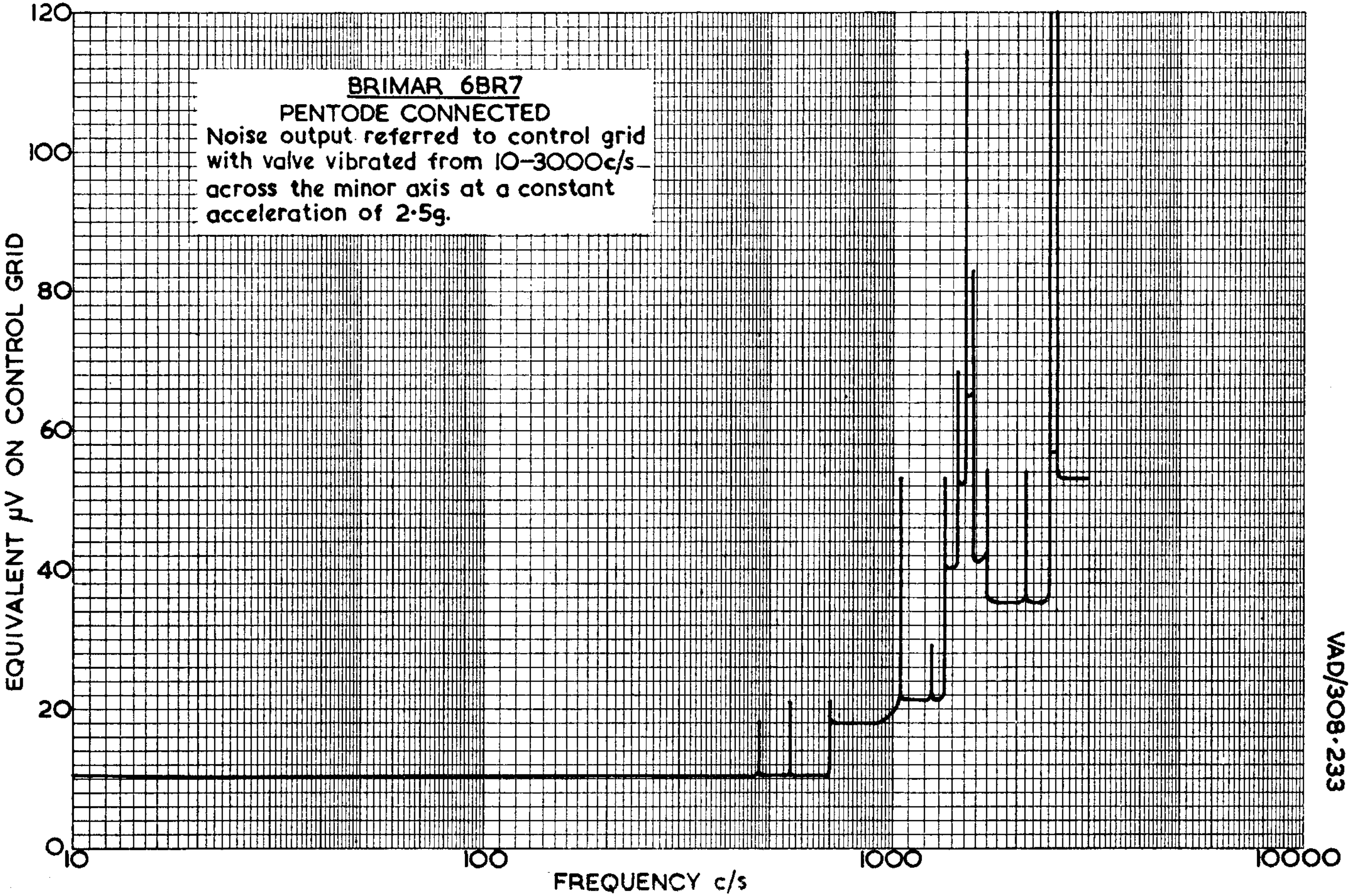
VAD/308-230
BRIMAR 6BR7
PENTODE CONNECTED
DISTRIBUTION OF HISS AS AN R.C.
COUPLED AMPLIFIER.
Control grid resistor Rg1=100kΩ
Cathode by pass condenser=50μF
Ra=220kΩ. Rg2=1·5MΩ
Rk=1·5kΩ Va(b)=300V
Bandwidth 10kc/s
100
80
60
40
20
0
PERCENTAGE OF VALVES
0
2
4
6
8
MAXIMUM HISS VOLTAGE REFERRED TO g1 μV


VAD/308·231
BRIMAR 6BR7
PENTODE CONNECTED
DISTRIBUTION OF HUM AS AN R.C.
COUPLED AMPLIFIER.
Control grid resistor Rg1=100kΩ
Cathode by-pass condenser=50μF
Bandwidth=340c/s
Heater pin 4 earthed
Ra=220kΩ Rg2=1·5MΩ
Ra=1·5kΩ Va(b)=300V
100
80
60
40
20
0
PERCENTAGE OF VALVES
0
20
40
60
80
MAXIMUM HUM REFERRED TO g1 μVOLTS



BRIMAR 6BR7
PENTODE CONNECTED
Noise output referred to control grid with valve vibrated from 10-3000c/s across the major axis at a constant acceleration of 2·5g.
EQUIVALENT µV ON CONTROL GRID
FREQUENCY c/s
120
100
80
60
40
20
0
10
100
1000
10000

VAD/308·232


BRIMAR 6BR7
PENTODE CONNECTED
Noise output referred to control grid with valve vibrated from 10–3000c/s– across the minor axis at a constant acceleration of 2·5g.
EQUIVALENT µV ON CONTROL GRID
FREQUENCY c/s
120
100
80
60
40
20
0
10
100
1000
10000
VAD/308·233

BRIMAR

RECEIVING VALVE

6BS7

APPLICATION REPORT VAD/508.4

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

Issued January, 1952.

1.0 INTRODUCTION: The Brimar 6BS7 is an indirectly heated screened pentode of miniature construction intended for use where low AF noise, microphony and hum are required, as in early stages of high gain AF amplifiers. The control grid is brought out to a top cap to reduce stray pick-up in the valve. The heater is intended for operation in parallel with those of other valves in AC operated equipment.

Very effective internal screening is employed, but the input and output capacitances are low enough to allow the valve to be used in RF applications up to frequencies of at least 20 Mc/s.

In this report are characteristic curves and details of the performance of the valve as a resistance capacity coupled amplifier. The anticipated levels of hum, hiss and microphony are given and the precautions necessary to ensure the best performance are discussed.

2.0 DESCRIPTION: The valve is a miniature screened pentode with characteristics similar in most ways to those of the 6J7 valve. The structure is mounted in a T6½ bulb and is fitted with a B9A (Noval) base. The whole assembly is designed with a view to obtaining the utmost possible rigidity. The control grid is screened internally from the heater to eliminate hum due to electrostatic pick-up from that source, and being connected to the top cap is well removed from pick-up from wiring to the base connections. The heater is wound in the form of a double spiral to reduce, as far as possible, the magnetic field set up by the heater current.

3.0 CHARACTERISTICS:

3.1 Cathode:	Indirectly heated	
	Voltage	6·3 volts
	Current (Nominal)	0·15 ampere
	Max. DC Heater-Cathode potential	100 volts
3.2 Dimensions:	Max. Overall Length	2-5/8 ins.
	Max. Diameter	7/8 in.
	Max. Seated Height	2-3/8 ins.
3.3 Base: Type B9A (Noval)	Pin 1 No Connection NC	
	Pin 2 Internal Connection IC	
	Pin 3 Cathode k	
	Pin 4 Heater h	
	Pin 5 Heater h	
	Pin 6 Internal Shield s	
	Pin 7 Anode a	
	Pin 8 Screen Grid g_2	
	Pin 9 Suppressor Grid g_3	
	Top Cap Control Grid g_1	

3.4 Ratings (Design centre):

PENTODE CONNECTED:

Max. Anode Voltage	300 volts
Max. Screen Voltage	125 volts
Max. Anode Dissipation	0·75 watts
Max. Screen Dissipation	0·3 watts

TRIODE CONNECTED (g_2 connected to anode, g_3 connected to cathode):

Max. Anode Voltage	250 volts
Max. Anode Dissipation	1·75 watts

3.5 Inter-electrode Capacitances (measured with no external shield):

PENTODE CONNECTED:

c_{in}	4·0 pF
c_{out}	4·0 pF
$c_{g1, a}$	0·01 pF

TRIODE CONNECTED:

c_{in}	3·0 pF
c_{out}	6·7 pF
$c_{g, a}$	1·1 pF

3.6 Characteristic Curves: Curves are included in this report which show:—

Anode current versus anode voltage (I_a/V_a) at various values of control grid voltage with a screen voltage (V_{g2}) of 125 volts, No. 308·237. Similar curves for a screen voltage of 100 volts are shown on No. 308·238, for V_{g2} 75 volts, No. 308·239, and for V_{g2} 50 volts, No. 308·240.

Anode current versus control grid voltage at various values of screen grid voltage, No. 308·242.

Anode current versus anode voltage with the valve connected as a triode, No. 308·241.

Mutual conductance and impedance versus control grid voltage for the valve connected as a pentode, No. 308·243.

Mutual conductance, impedance and amplification factor versus grid voltage for the valve connected as a triode, No. 308·244.

4.0 TYPICAL OPERATION:

4.1 PENTODE CONNECTED (g_3 connected to cathode):

Heater Voltage	6·3	6·3	volts
Anode Voltage	100	250	volts
Screen Voltage	100	100	volts
Grid Voltage	—3	—3	volts
Cathode Bias Resistor	1100	1100	ohms
Anode Current	2·0	2·1	mA
Screen Current	0·7	0·6	mA
Anode Impedance	1·5	2·4	MΩ
Mutual Conductance	1·1	1·25	mA/V
Inner Amplification Factor	20	20	
Grid Voltage for 1/100 g_m at V_{g1} — —3	—8	—9	volts

4.2 TRIODE CONNECTED (g_2 connected to anode, g_3 connected to cathode):

Heater Voltage	6·3	volts
Anode Voltage	250	volts
Grid Voltage	—8	volts
Anode Current	6·5	mA
Mutual Conductance	1·72	mA/V
Anode Impedance	11,600	ohms
Amplification Factor	20	

5.0 OPERATION AS A RESISTANCE CAPACITY COUPLED AF AMPLIFIER:

5.1 Pentode Connected: In the table below are given typical operating conditions under various conditions of anode load and supply voltage which yield an output with approximately 5% distortion.

Anode Supply Voltage		100			300		volts
Anode Load Resistor	100	220	470	100	220	470	kΩ
Cathode Bias Resistor	1·3	3·3	5·6	0·56	1·5	2·2	kΩ
Series Screen Resistor	0·47	1·5	2·8	0·47	1·5	2·8	MΩ
Succeeding Stage Grid Resistor	1·0	1·0	1·0	1·0	1·0	1·0	MΩ
Peak Output Voltage	21	28	31	70	92	100	volts
Voltage Gain	65	80	140	104	124	185	

Included in this report are curves of anode and screen current versus control grid voltage taken with a supply voltage of 250 volts and various values of anode load resistor. The characteristics for an anode load of 100 kΩ are given on No. 308·247, for 220 kΩ on No. 308·246 and for 470 kΩ on No. 308·245. The method of using these curves for calculating the resistance capacity coupled amplifier performance is as follows:

As an example, assume it is desired to operate with a load resistor of 220 kΩ and a succeeding valve grid leak of 1 MΩ. It can be seen from the curve that control grid current sets in at about —0·5 volts, so that the bias should be chosen to prevent excursion into voltages lower than this. If a value of —2·0 volts is selected, a reasonably linear I_a/V_{g1} characteristic is obtained with the screen grid operating at 50 volts. With such an operating point the anode current is 0·48 mA, and the screen current 0·23 mA. The cathode bias resistor will be $\frac{2{\cdot}0 \times 1000}{0{\cdot}48 + 0{\cdot}23}$ or 2800 ohms.

The series screen resistor will be $\frac{200 \times 1000}{0{\cdot}23}$ or 0·87 MΩ.

Allowing a peak input voltage of 0·3 volt, the grid will swing from —2·3 to —1·7 volts, giving an anode current swing of 0·32 mA to 0·68 mA, or 0·36 mA peak to peak. In a 220 kΩ load this corresponds to an output voltage of 79 volts peak to peak or 39·5 volts peak. The voltage gain is then 131 times.

As allowance must be made for the following grid leak of 1 MΩ, these figures must be reduced by a factor of $\frac{10^6}{10^6 + 0{\cdot}22 \times 10^6}$ or 0·82. The stage gain is then 108 times and the output voltage 32·5 volts peak.

The distortion may be estimated by inspection of the relative stage gains at the positive and negative peaks of the signal. The gain at —2·3 volts is

$$\frac{(0{\cdot}48 - 0{\cdot}32) \times 220 \times 0{\cdot}82}{0{\cdot}3} \text{ or } 96{\cdot}5 \text{ times.}$$

The gain at —1·7 volts is $\frac{(0{\cdot}68 - 0{\cdot}48) \times 220 \times 0{\cdot}82}{0{\cdot}3}$ or 120 times.

The distortion is then:

$$\frac{120 - \left(\frac{120 + 96{\cdot}5}{2}\right)}{120 + 96{\cdot}5} \times 100 = 5{\cdot}3\%$$

5.2 Triode Connected: The valve may be used as a low μ triode resistance capacity coupled amplifier where the requirements for low hum and noise outweigh these for high gain. In the table below are given typical operating conditions under various conditions of anode load and supply voltage which yield an output with approximately 5% distortion.

Anode Voltage		100			300		volts
Anode Load Resistance	100	220	470	100	220	470	kΩ
Cathode Bias Resistor	7·5	14·5	20·0	6·0	14·0	18·6	kΩ
Succeeding Stage Grid Resistor	0·5	1·0	1·0	0·5	1·0	1·0	MΩ
Peak Output Voltage	22	26	28	88	96	105	volts
Stage Gain	12	13	14	13	14	14	times

A curve, No. 308·248, is included in the report, which shows the relation between the various valve parameters and control grid voltage under conditions of RC coupled operation with various values of anode load resistance.

A method of using this curve for calculating performance is as follows. If it is desired to use an anode load of 220 kΩ with a supply of 250 volts, inspection of the curves indicates a reasonably linear portion over the region of grid voltage —2 to —8 volts. Assuming an operating point at —5 volts the anode impedance and amplification factor are shown as 27·2 kΩ and 17 respectively. The anode load is effectively in parallel with the following valve grid leak, and if this is 1 MΩ the effective load is $\frac{220 \times 1000}{1220}$ or 180 kΩ.

The stage gain is then $\frac{\mu R_a}{R_a + r_a} = \frac{17 \times 180}{207{\cdot}2}$ or 14 times.

The distortion may be estimated in the same way as for pentode operation by calculating the stage gain at the extremes of the input signal.

6.0 LOW HUM APPLICATIONS:

6.1 Pentode Connected: Due to the extensive internal screening very little magnetic and electrostatic hum pick-up occur in the electrode structure. The double ended construction with the grid connection well separated from the heater wiring enables the grid to heater capacity to be reduced to a negligible value, with the result that hum levels below 1μV referred to the grid are obtainable.

Curve No. 308·249 shows the maximum hum level referred to the grid plotted against the percentage of valves giving this level, or less, with a grid circuit impedance of 100 kΩ. A hum balancing resistor with its slider connected to earth was connected across the heater. From this curve it can be estimated how many samples from a large batch will have a hum level below a certain value. It will be seen that to expect a hum level of the order of 2μV is reasonable as 90% of the valves would be better than this.

In order to achieve low hum levels from this valve in the first stage of a high gain amplifier, precautions must be taken to see that the valve is not situated in any AC fields from chokes, transformers or heater wiring. Similar precautions must also be taken with the input wiring, and decoupling earth returns pertaining to the stage should be connected to a single point and not distributed around the chassis forming closed loops liable to couple with AC magnetic fields.

A screened top cap connector is necessary to obtain the full low hum advantages from the 6BS7. An external screen around the bulb is desirable, as although an internal screen is provided, the effect of electrostatic charges on the glass envelope is not entirely eliminated, nor can a single screen give complete protection from strong magnetic fields. If the valve is not being used at very low input levels the external screen will not be required.

Although the figures shown on Curve No. 308·249 were measured with a hum balancing resistor across the heater, in general, direct earthing of one heater pin will result in only slightly increased hum from valves otherwise exhibiting the lowest hum levels.

The figures quoted for hum were obtained with a grid leak of 100 kΩ. Wherever possible the grid circuit impedance should be limited to this figure. A higher value is permissible, but the danger of electrostatic pick-up is increased.

6.2 Triode Connected: The same considerations apply as in paragraph 6.1 with regard to precautions to ensure low hum. Triode connection yields even lower hum levels than pentode connection. No curve of expected hum level is given as it was found impossible to obtain reliable measurements at such low levels.

Both pentode and triode connection hum levels are affected by the anode current. All the figures quoted are for RC coupled amplifiers, where the anode current is less than 1 mA. If the valve is operated with a choke or transformer load the anode current should be held below 1·5 mA to maintain low hum level.

7.0 Microphony: It is not possible to specify the microphony level because this is so much dependent on the circumstances of the application. The valve has been designed with a very rigid structure to minimise the effect of vibration, but there will always be some movement of individual grid wires when vibrated at their resonant frequency. By careful design, all low frequency resonances due to loose electrodes have been removed, so that there are no internal resonances below 1000c/s. This is shown on the curves No. 308·252 and 308·253, which indicate the amplitude of the resonances when the valve is vibrated across the major and minor axes respectively. The frequency of vibration was varied from 10 to 3000 c/s with a constant acceleration of 2·5g.

It is interesting to note that the amplitude of vibration to produce an acceleration of 2·5g varies from 0·25 in. at 10 c/s to approximately 0·001 in. at 150 c/s, while at 5000 c/s the peak amplitude is only two millionths of an inch. Most of the higher frequency vibrations are heavily damped by the chassis and valve holder mounting. The use of an antimicrophonic type of valveholder usually eliminates vibration effects at these frequencies.

Where the valve is being used at the limit of its sensitivity it is important to minimise as far as possible by flexible valve holder mountings all mechanical and acoustical vibrations. This is particularly important where the valve is included in the same cabinet as the loudspeaker, or a motor, such as in magnetic tape recorders and sound film projectors.

8.0 Valve Shot Noise (Hiss): A certain amount of random noise will be generated in the valve by the random arrival of electrons at the anode, and this is further increased by the partition of the cathode current between anode and screen, as the random collection of electrons by the screen must have its effect as an increased variation in the number of electrons arriving at the anode. This is inherent in the valve and cannot be entirely eliminated. A major contribution to valve noise, however, is noise produced by leakage between electrodes over the mica insulators and stray fibres or "lint" between electrodes. Also a poorly activated cathode can produce a noise voltage swamping the normal valve noise.

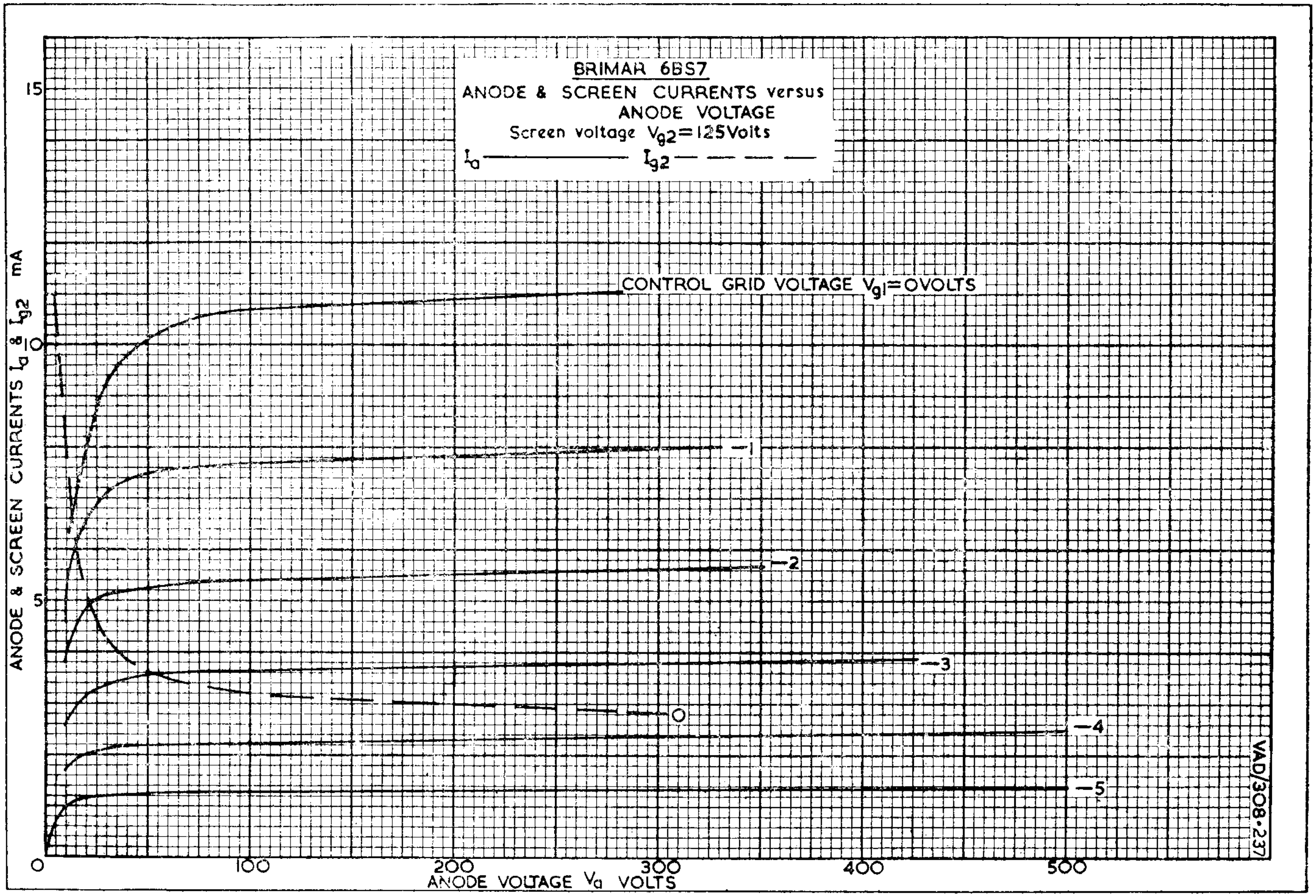
The shot noise in the 6BS7 has been reduced to a minimum by careful design, and the noise due to leakage controlled by careful assembly and inspection. A certain amount of leakage noise is unavoidable in a mass produced valve, and this reveals itself as a small variation in noise level from valve to valve.

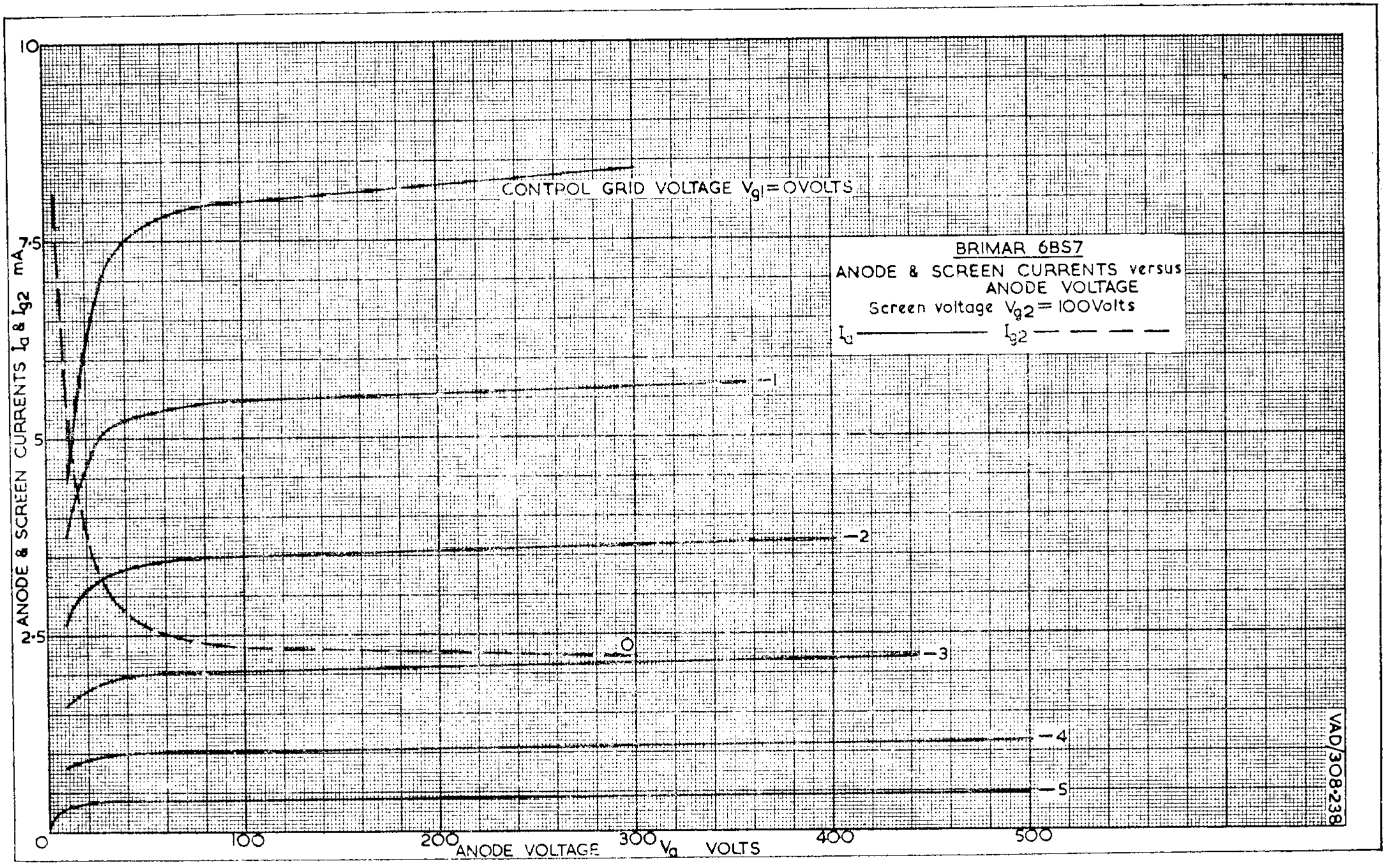
The Curve No. 308·250 shows the maximum hiss voltage plotted against the percentage of valves, using a grid resistor of 100 kΩ and a bandwidth of 10 kc/s. The curve is very steep, and indicates that a hiss level on the grid always lower than 7μV is to be expected.

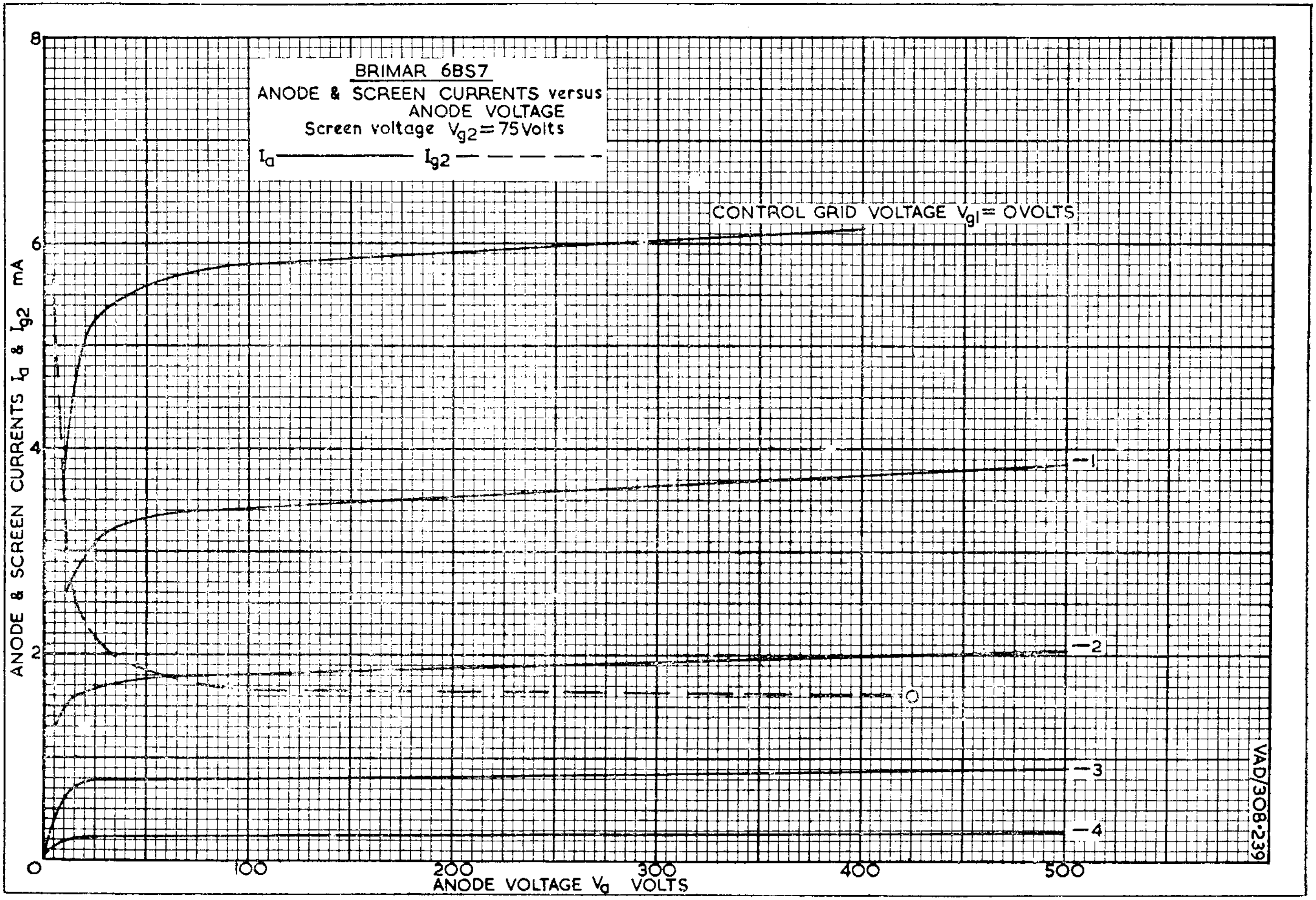
The Curve No. 308·251 shows the same parameters with the valve triode connected. Here partition noise has been eliminated. As would be expected the higher noise levels are unaltered because they are due mainly to leakage which is not greatly affected by whether the valve is triode or pentode connected. The lower noise level is reduced, and in fact falls below the thermal agitation noise generated by the 100 kΩ grid resistor, which in a 10 kc/s bandwidth at 20° C is about 4μV.

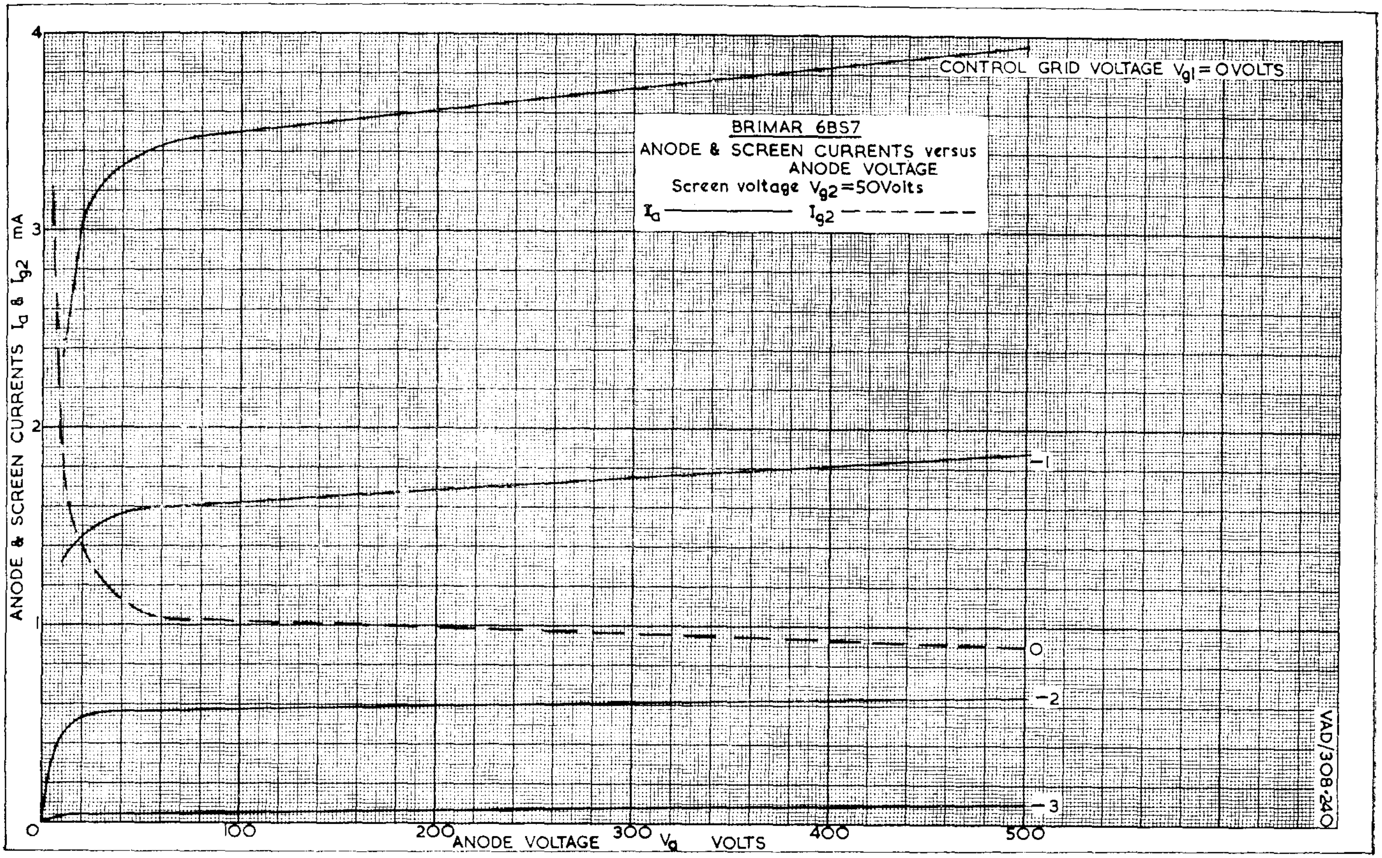
9.0 Other Applications: By virtue of the precautions taken to ensure low grid leakage, the 6BS7 may be of use where a valve with exceptionally low control grid current is required and the use of a special electrometer valve is not warranted. Curve No. 308·254 shows the maximum control grid current plotted against the number of valves giving this value or less. This is for the valve connected as a triode with an anode voltage of 100 volts and grid bias of —3 volts. 50% of the valves show a grid current of less than 10^{-3}μA.

The value of grid current is affected, in the case of valves with lowest leakage, by incident light due to stray photo-emission. The figures quoted are for normal room daylight, and some improvement may be obtained by shielding the valve from incident light.

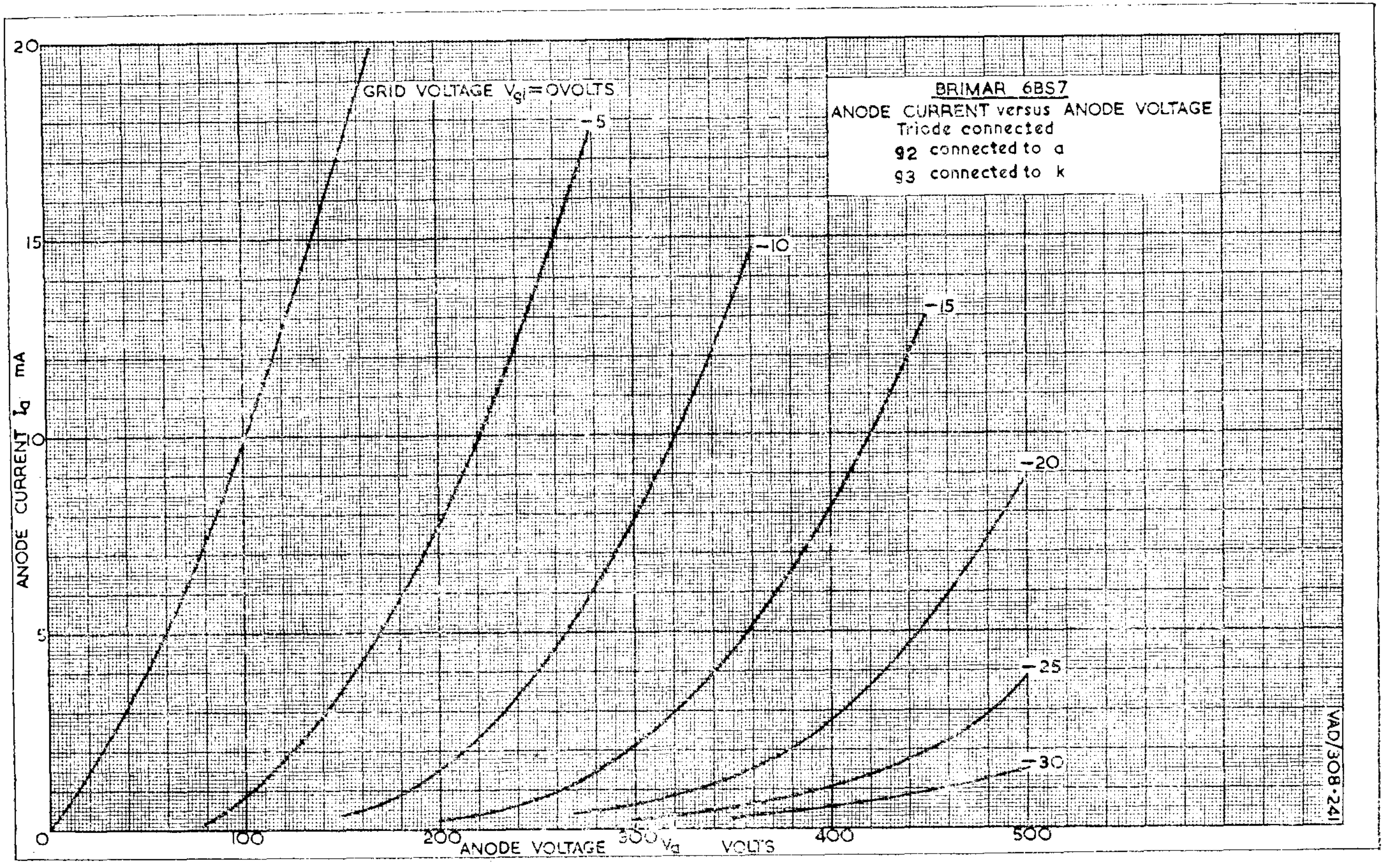

BRIMAR 6BS7
ANODE & SCREEN CURRENTS versus ANODE VOLTAGE
Screen voltage V_{g2}=125 Volts
I_a ——— I_{g2} — — —
CONTROL GRID VOLTAGE V_{g1}=0 VOLTS
−1
−2
−3
0
−4
−5
ANODE & SCREEN CURRENTS I_a & I_{g2} mA
15
10
5
0
100
200
300
400
500
ANODE VOLTAGE V_a VOLTS
VAD/308·237


BRIMAR 6BS7
ANODE & SCREEN CURRENTS versus ANODE VOLTAGE
Screen voltage V_{g2} = 100 Volts
I_a ——— I_{g2} — — —
CONTROL GRID VOLTAGE V_{g1} = 0 VOLTS
0
−1
−2
−3
−4
−5
ANODE & SCREEN CURRENTS I_a & I_{g2} mA
10
7·5
5
2·5
0
100
200
300
400
500
ANODE VOLTAGE V_a VOLTS
VAD/308·238

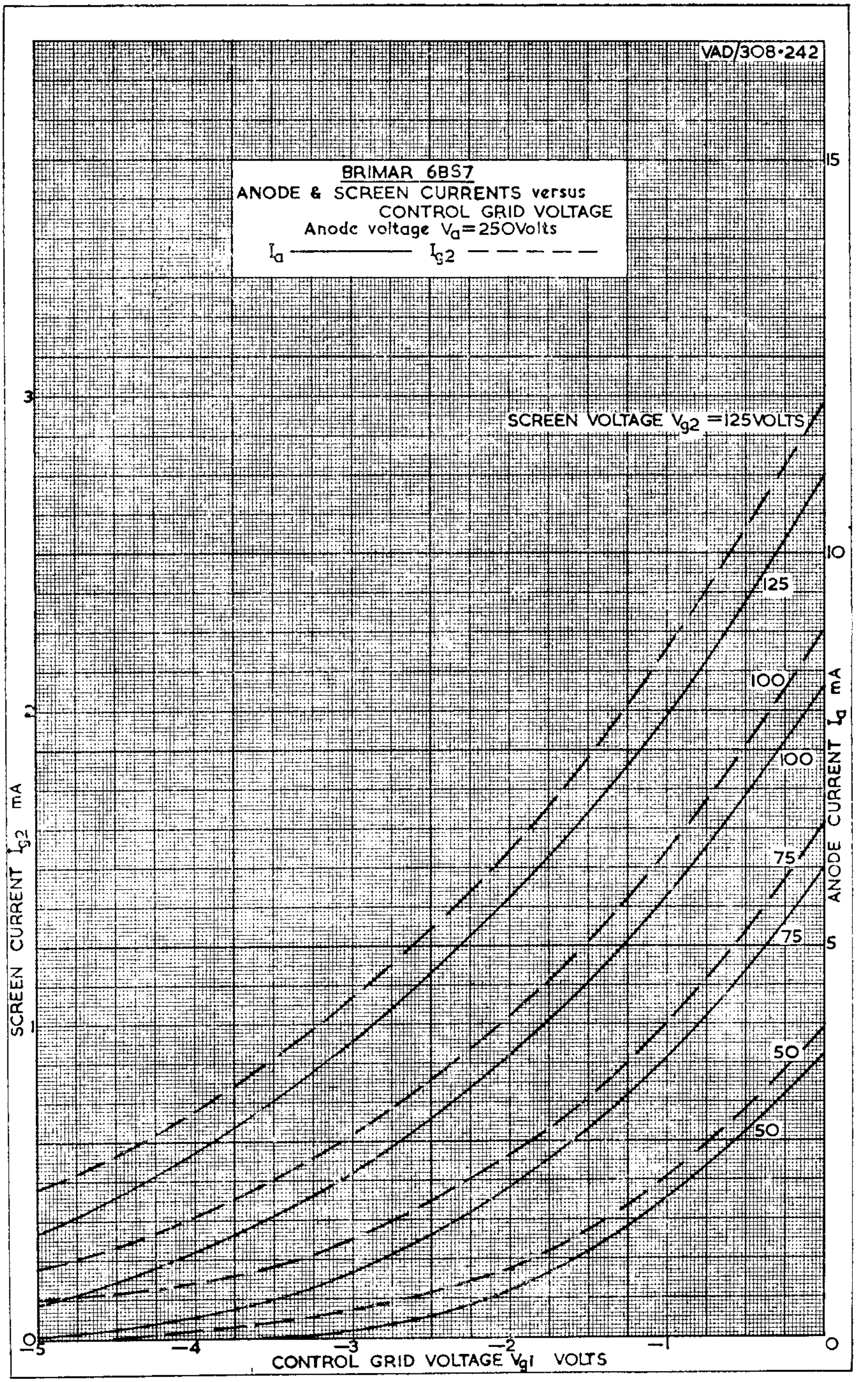

BRIMAR 6BS7
ANODE & SCREEN CURRENTS versus ANODE VOLTAGE
Screen voltage V_{g2} = 75 Volts
I_a ——— I_{g2} – – – –
CONTROL GRID VOLTAGE V_{g1} = 0 VOLTS
−1
−2
0
−3
−4
ANODE & SCREEN CURRENTS I_a & I_{g2} mA
ANODE VOLTAGE V_a VOLTS
0
100
200
300
400
500
2
4
6
8
VAD/308·239



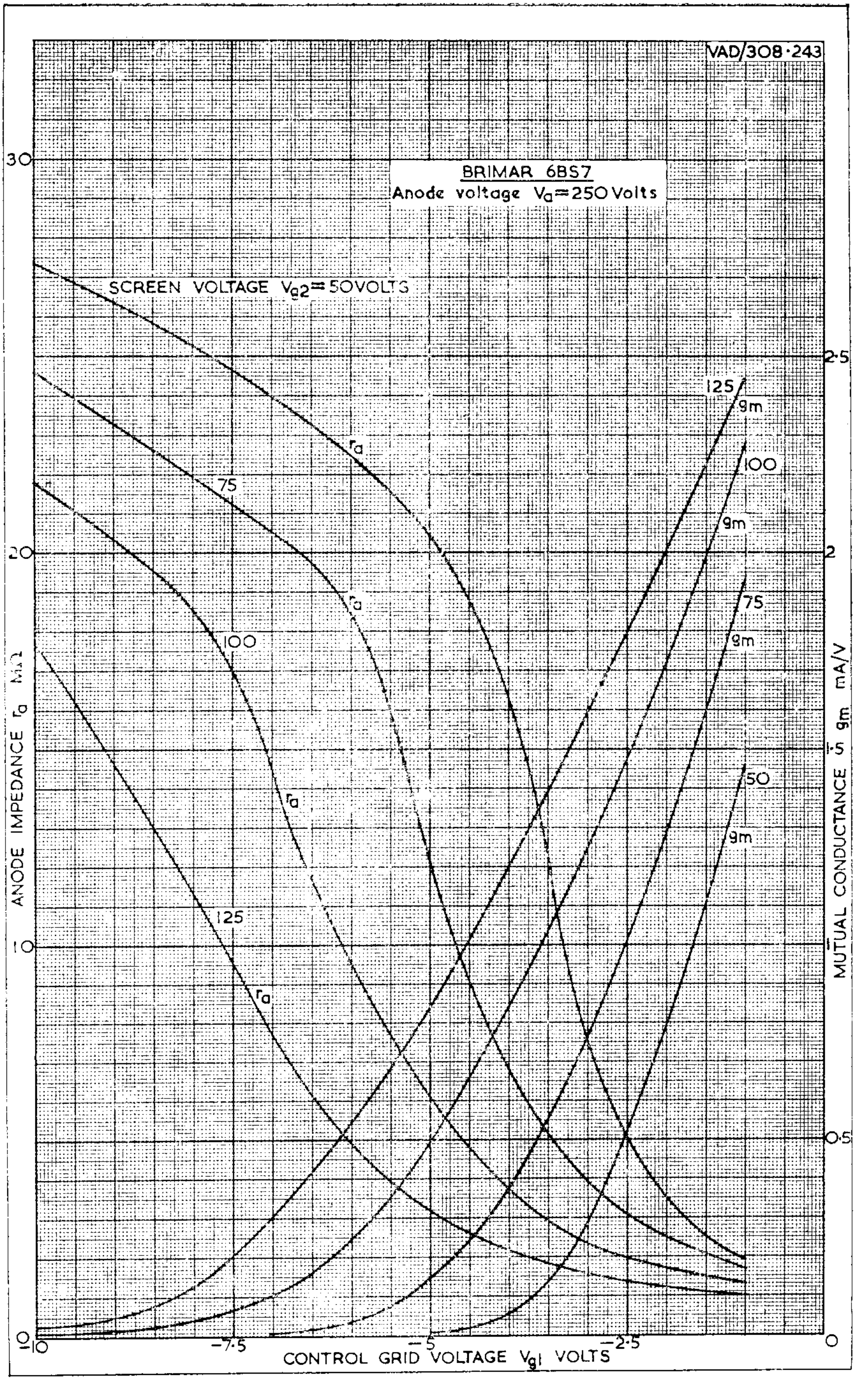
BRIMAR 6BS7
ANODE & SCREEN CURRENTS versus ANODE VOLTAGE
Screen voltage V_{g2}=50Volts
I_a ———— I_{g2} – – – –
CONTROL GRID VOLTAGE V_{g1}=0VOLTS
-1
0
-2
-3
ANODE & SCREEN CURRENTS I_a & I_{g2} mA
ANODE VOLTAGE V_a VOLTS
0
100
200
300
400
500
1
2
3
4
VAD/308·240



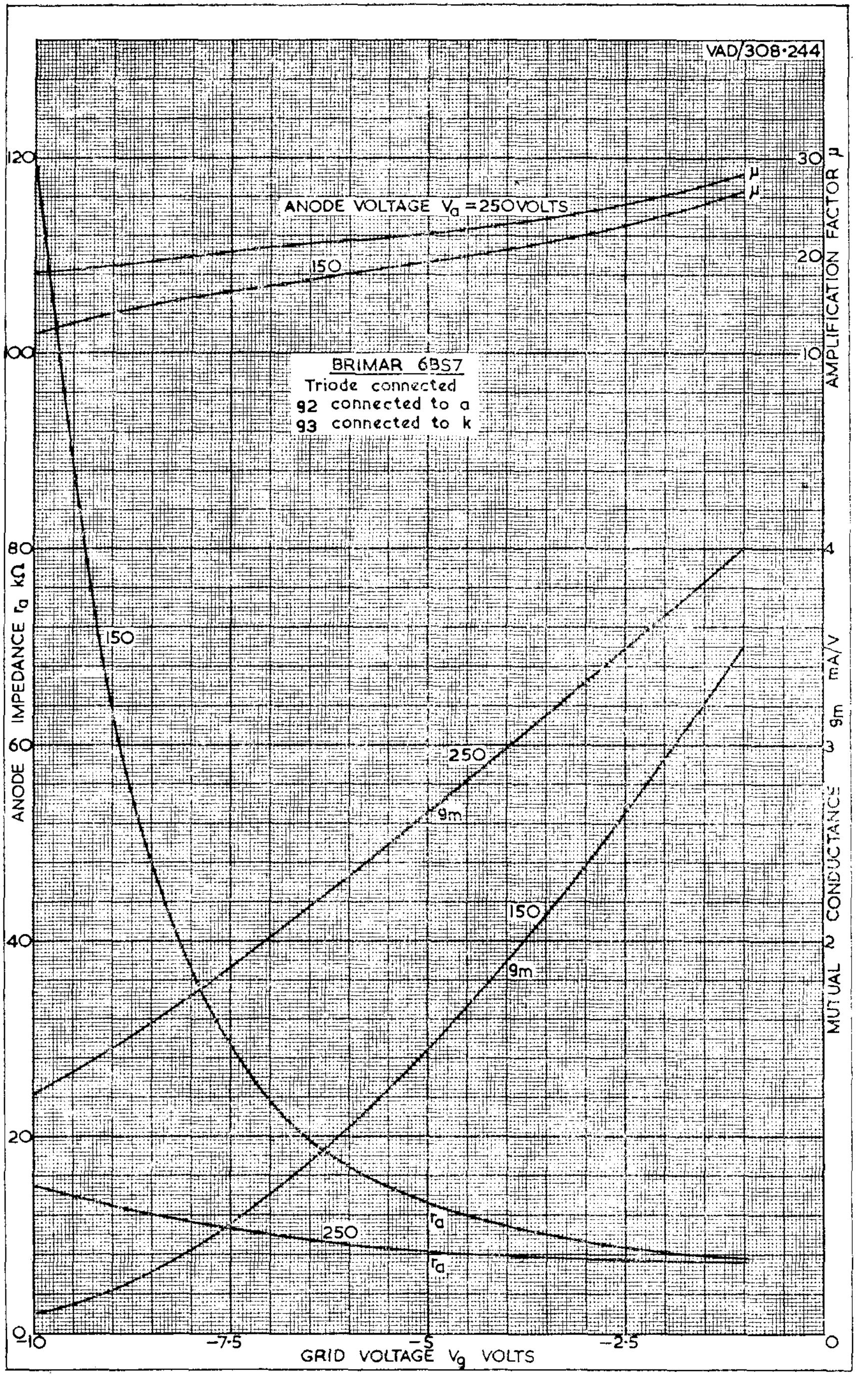
BRIMAR 6BS7
ANODE CURRENT versus ANODE VOLTAGE
Triode connected
g2 connected to a
g3 connected to k
GRID VOLTAGE Vg1 = 0 VOLTS
−5
−10
−15
−20
−25
−30
ANODE CURRENT Ia mA
ANODE VOLTAGE Va VOLTS
0
5
10
15
20
100
200
300
400
500
VAD/308·241



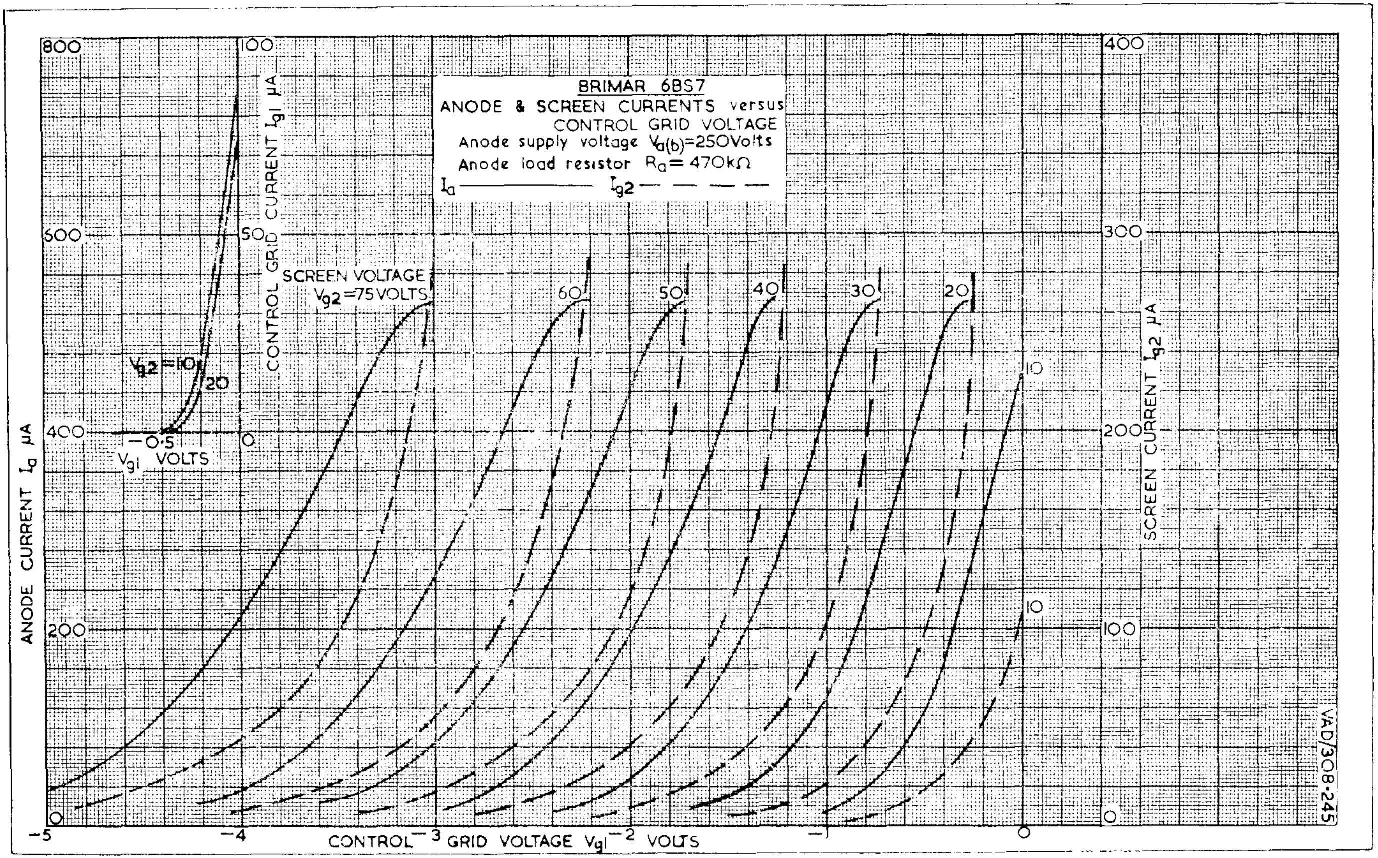
VAD/308·242
BRIMAR 6BS7
ANODE & SCREEN CURRENTS versus CONTROL GRID VOLTAGE
Anode voltage Va=250Volts
Ia ——— Ig2 — — —
SCREEN VOLTAGE Vg2 =125VOLTS
125
100
100
75
75
50
50
SCREEN CURRENT Ig2 mA
ANODE CURRENT Ia mA
CONTROL GRID VOLTAGE Vg1 VOLTS
−5
−4
−3
−2
−1
0
1
2
3
5
10
15

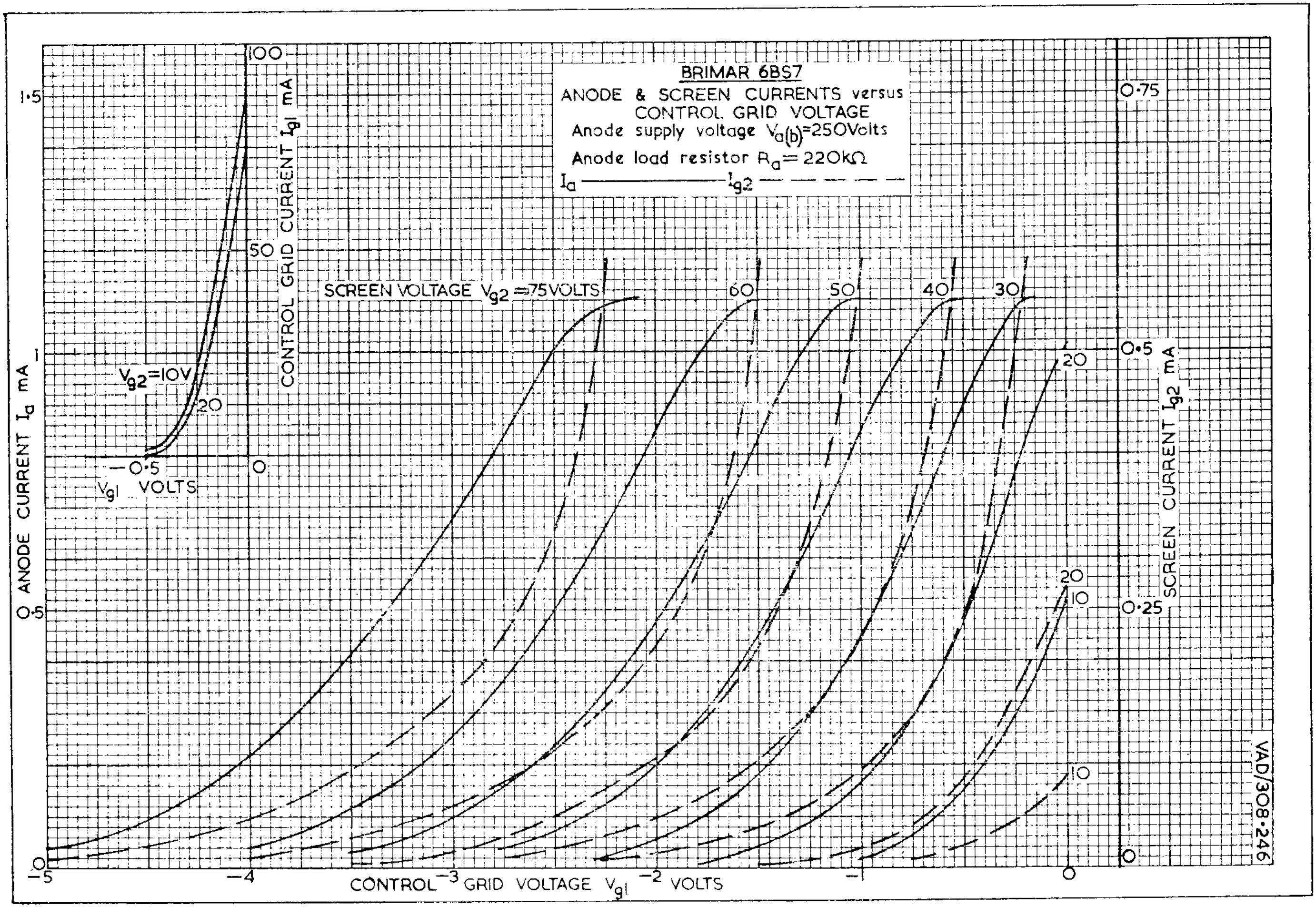


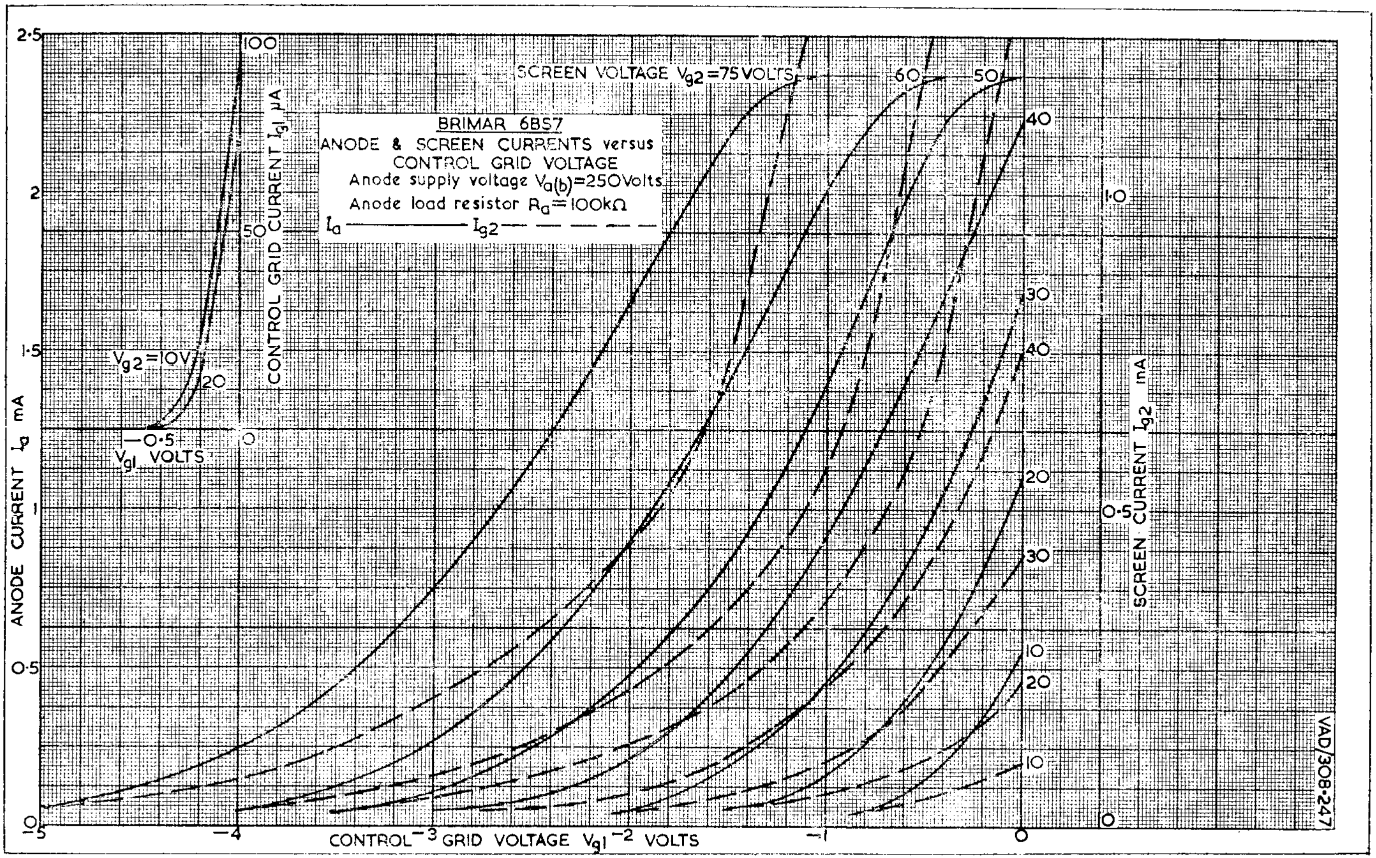
VAD/308·243
BRIMAR 6BS7
Anode voltage V_a=250 Volts
SCREEN VOLTAGE V_{g2}=50 VOLTS
ANODE IMPEDANCE r_a MΩ
MUTUAL CONDUCTANCE g_m mA/V
CONTROL GRID VOLTAGE V_{g1} VOLTS
30
20
10
0
2·5
2
1·5
1
0·5
0
-10
-7·5
-5
-2·5
75
100
125
r_a
125
100
75
50
g_m



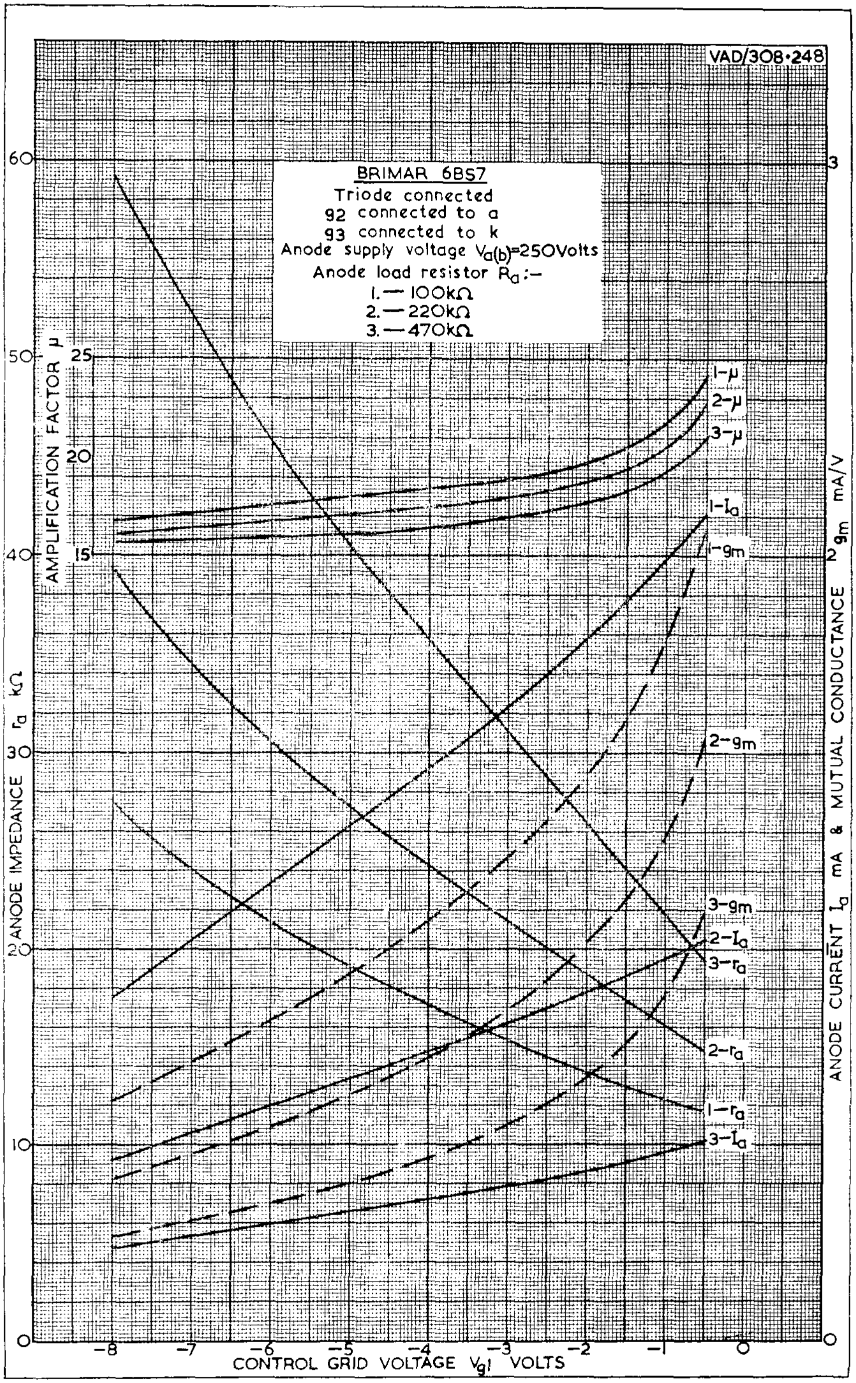
VAD/308·244
ANODE VOLTAGE V_a = 250 VOLTS
150
μ
μ
BRIMAR 6BS7
Triode connected
g2 connected to a
g3 connected to k
150
250
gm
150
gm
250
r_a
r_a
ANODE IMPEDANCE r_a kΩ
AMPLIFICATION FACTOR μ
MUTUAL CONDUCTANCE gm mA/V
GRID VOLTAGE V_g VOLTS
120
100
80
60
40
20
0
30
20
10
4
3
2
0
-10
-7·5
-5
-2·5
0

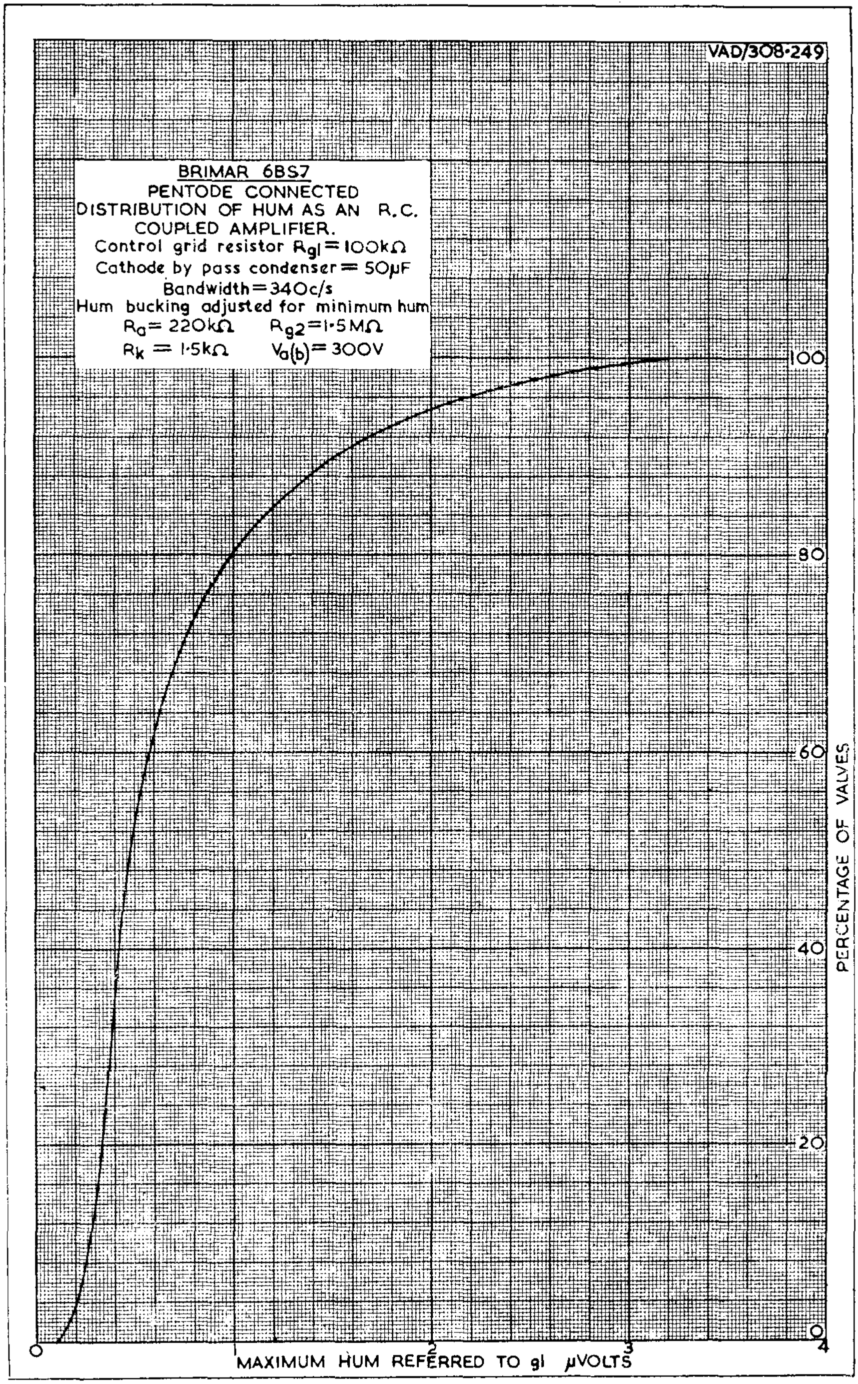

BRIMAR 6BS7
ANODE & SCREEN CURRENTS versus CONTROL GRID VOLTAGE
Anode supply voltage $V_{a(b)}$=250Volts
Anode load resistor R_a= 470kΩ
I_a ——— I_{g2} — — —
SCREEN VOLTAGE V_{g2}=75VOLTS
60
50
40
30
20
10
10
V_{g2}=10
20
−0·5
V_{g1} VOLTS
CONTROL GRID CURRENT I_{g1} μA
100
50
0
ANODE CURRENT I_a μA
800
600
400
200
0
SCREEN CURRENT I_{g2} μA
400
300
200
100
0
CONTROL GRID VOLTAGE V_{g1} VOLTS
−5
−4
−3
−2
−1
0
VAD/308·245

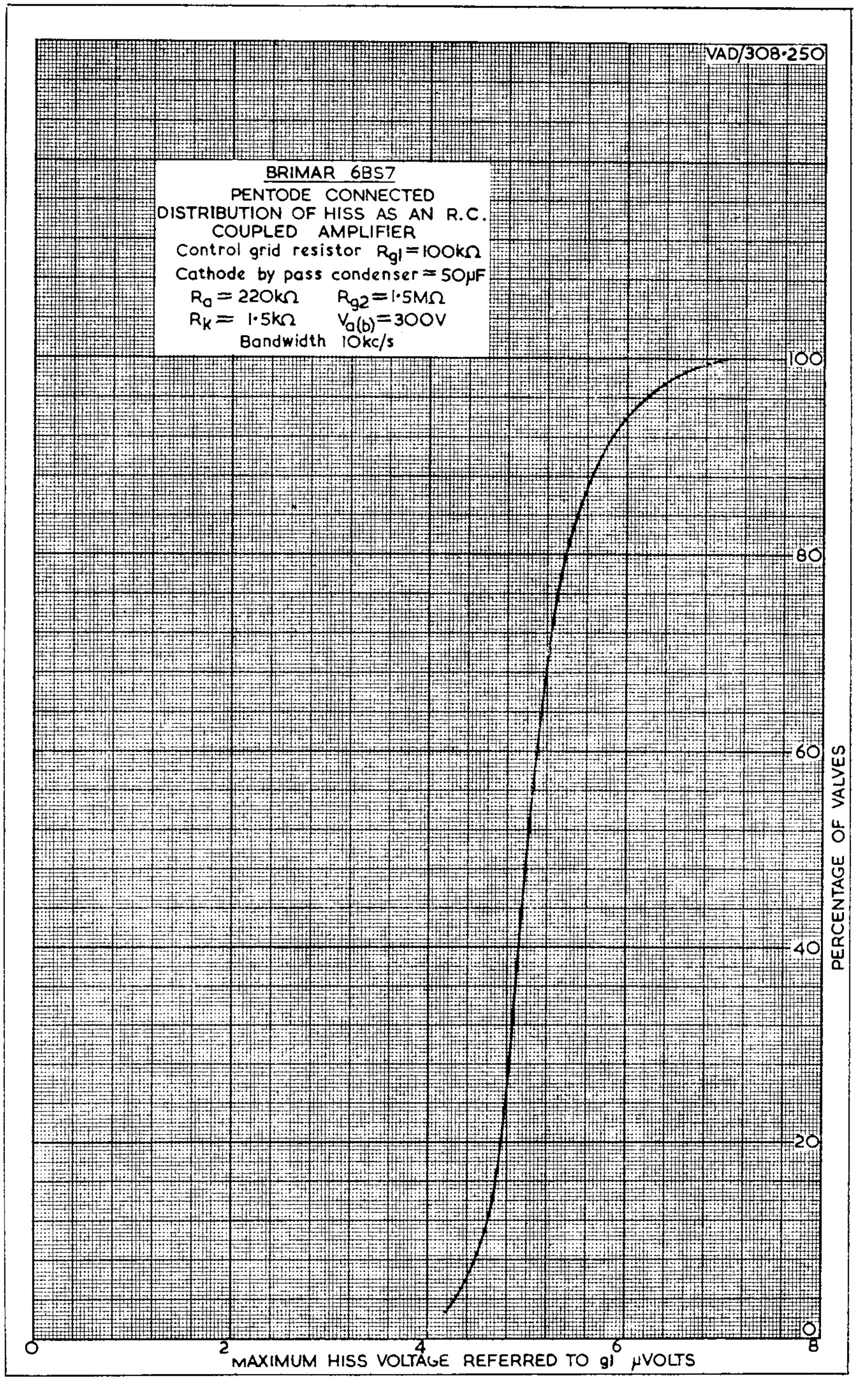

BRIMAR 6BS7
ANODE & SCREEN CURRENTS versus CONTROL GRID VOLTAGE
Anode supply voltage $V_{a(b)}$=250Volts
Anode load resistor R_a= 220kΩ
I_a ——— I_{g2} – – –
SCREEN VOLTAGE V_{g2}=75VOLTS
60
50
40
30
20
10
V_{g2}=10V
20
CONTROL GRID CURRENT I_{g1} mA
100
50
0
−0·5
V_{g1} VOLTS
ANODE CURRENT I_a mA
1·5
1
0·5
0
SCREEN CURRENT I_{g2} mA
0·75
0·5
0·25
0
CONTROL GRID VOLTAGE V_{g1} VOLTS
−5
−4
−3
−2
−1
0
VAD/308·246



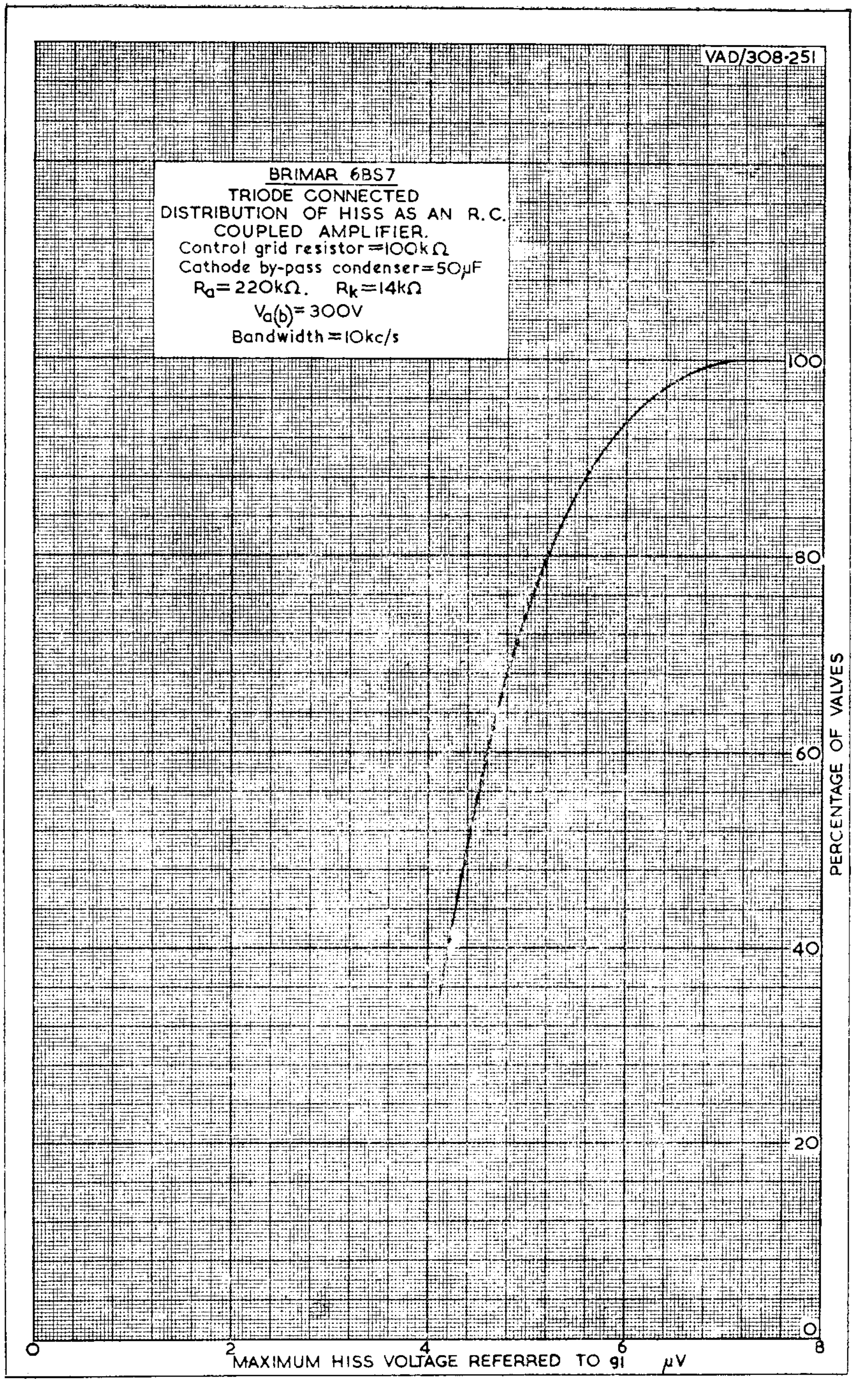
BRIMAR 6BS7
ANODE & SCREEN CURRENTS versus CONTROL GRID VOLTAGE
Anode supply voltage $V_{a(b)}$=250 Volts
Anode load resistor R_a=100kΩ
I_a ——— I_{g2} — — —
SCREEN VOLTAGE V_{g2}=75 VOLTS
60
50
40
30
40
20
30
10
20
10
V_{g2}=10V
20
—0·5
V_{g1} VOLTS
CONTROL GRID CURRENT I_{g1} μA
100
50
0
SCREEN CURRENT I_{g2} mA
1·0
0·5
0
ANODE CURRENT I_a mA
2·5
2
1·5
1
0·5
0
CONTROL GRID VOLTAGE V_{g1} VOLTS
−5
−4
−3
−2
−1
0
VAD/308·247

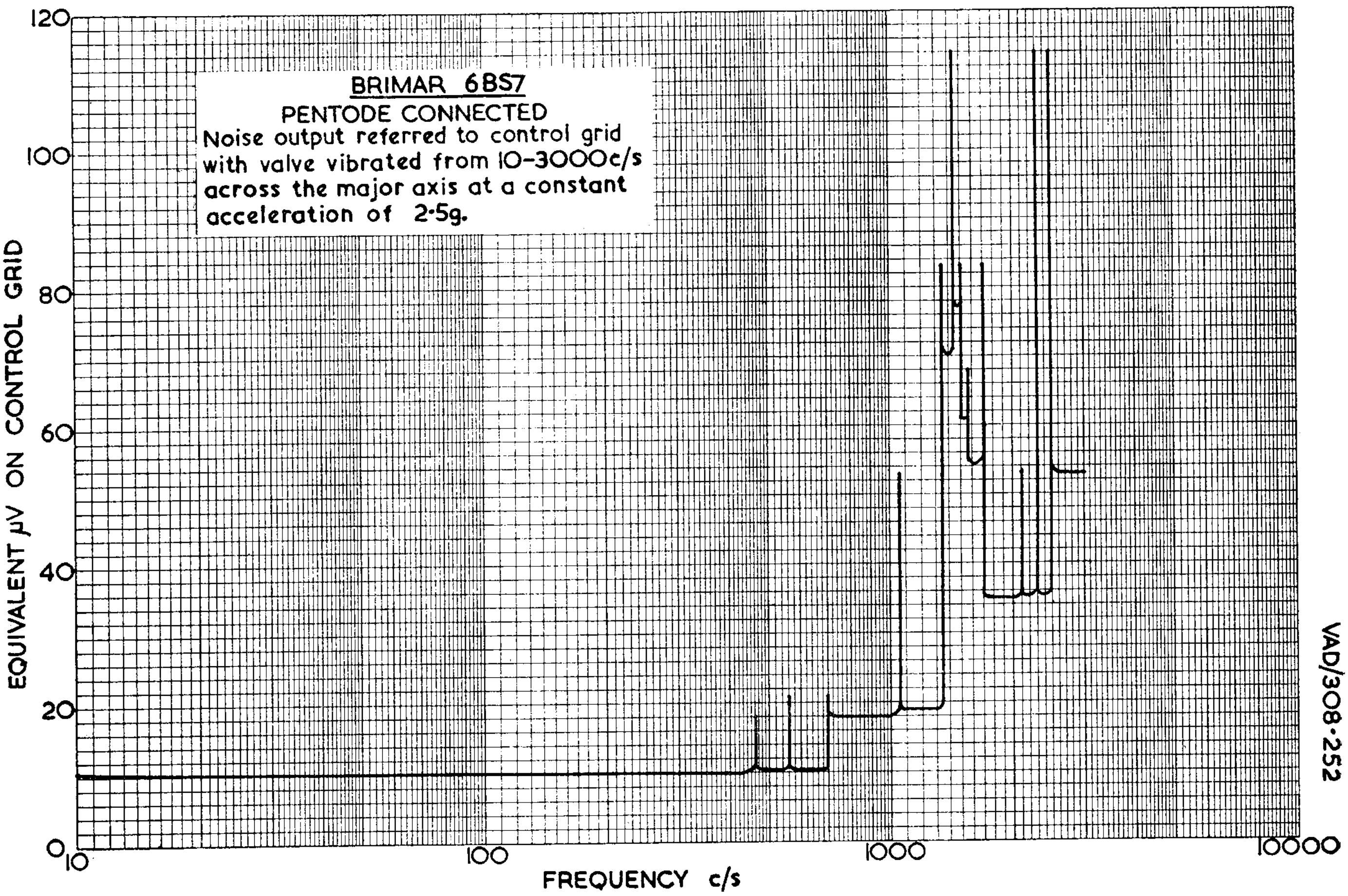

VAD/308·248
BRIMAR 6BS7
Triode connected
g2 connected to a
g3 connected to k
Anode supply voltage Va(b)=250Volts
Anode load resistor Ra:-
1.— 100kΩ
2.— 220kΩ
3.— 470kΩ
1-μ
2-μ
3-μ
1-Ia
1-gm
2-gm
3-gm
2-Ia
3-ra
2-ra
1-ra
3-Ia
AMPLIFICATION FACTOR μ
ANODE IMPEDANCE ra kΩ
ANODE CURRENT Ia mA & MUTUAL CONDUCTANCE gm mA/V
CONTROL GRID VOLTAGE Vg1 VOLTS
60
50
40
30
20
10
0
25
20
15
3
2
0
−8
−7
−6
−5
−4
−3
−2
−1
0

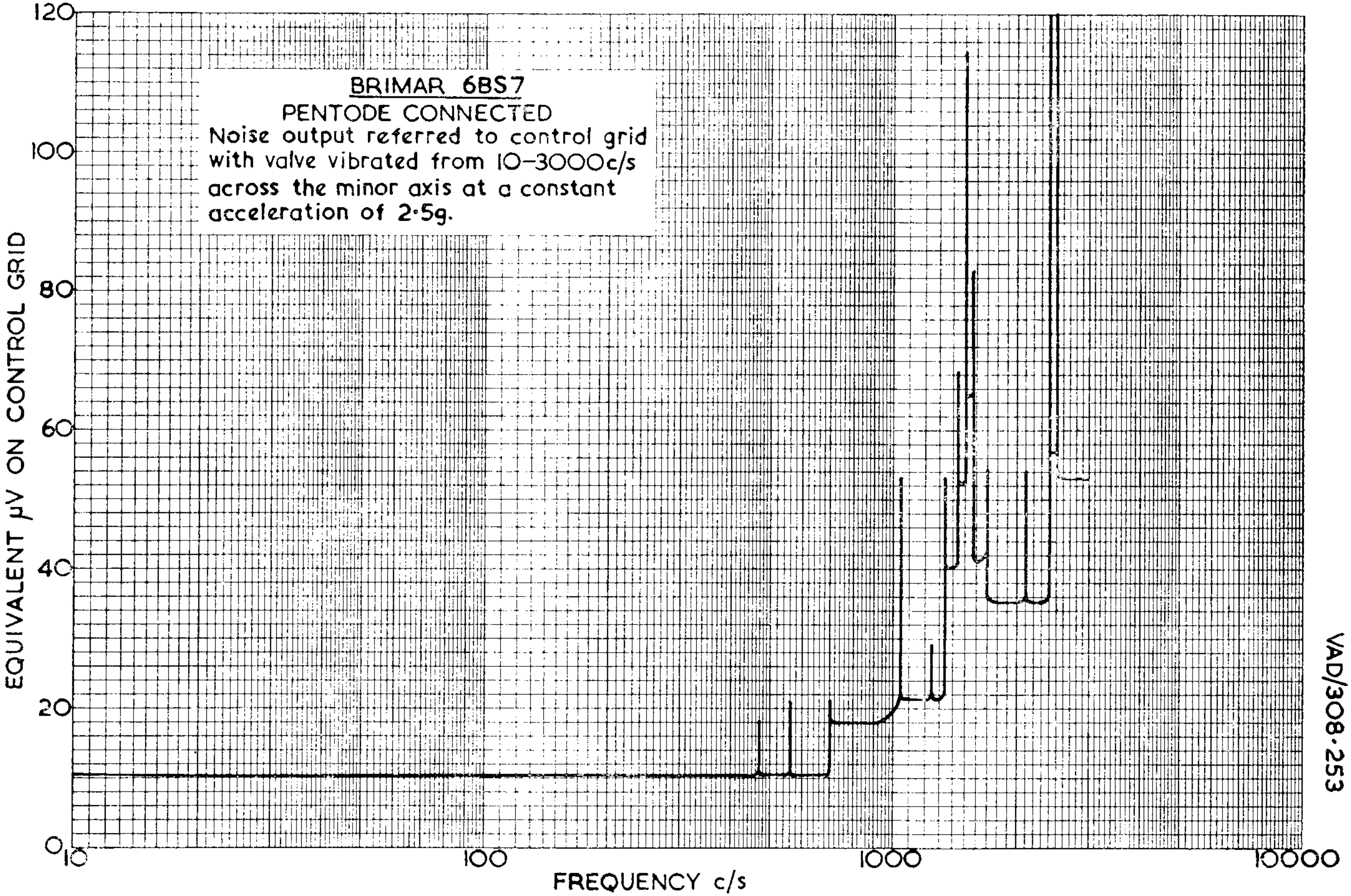

VAD/308·249
BRIMAR 6BS7
PENTODE CONNECTED
DISTRIBUTION OF HUM AS AN R.C. COUPLED AMPLIFIER.
Control grid resistor R_{g1} = 100kΩ
Cathode by pass condenser = 50μF
Bandwidth = 340c/s
Hum bucking adjusted for minimum hum
R_a = 220kΩ R_{g2} = 1·5MΩ
R_k = 1·5kΩ $V_{a(b)}$ = 300V
100
80
60
40
20
0
PERCENTAGE OF VALVES
0
1
2
3
4
MAXIMUM HUM REFERRED TO g1 μVOLTS



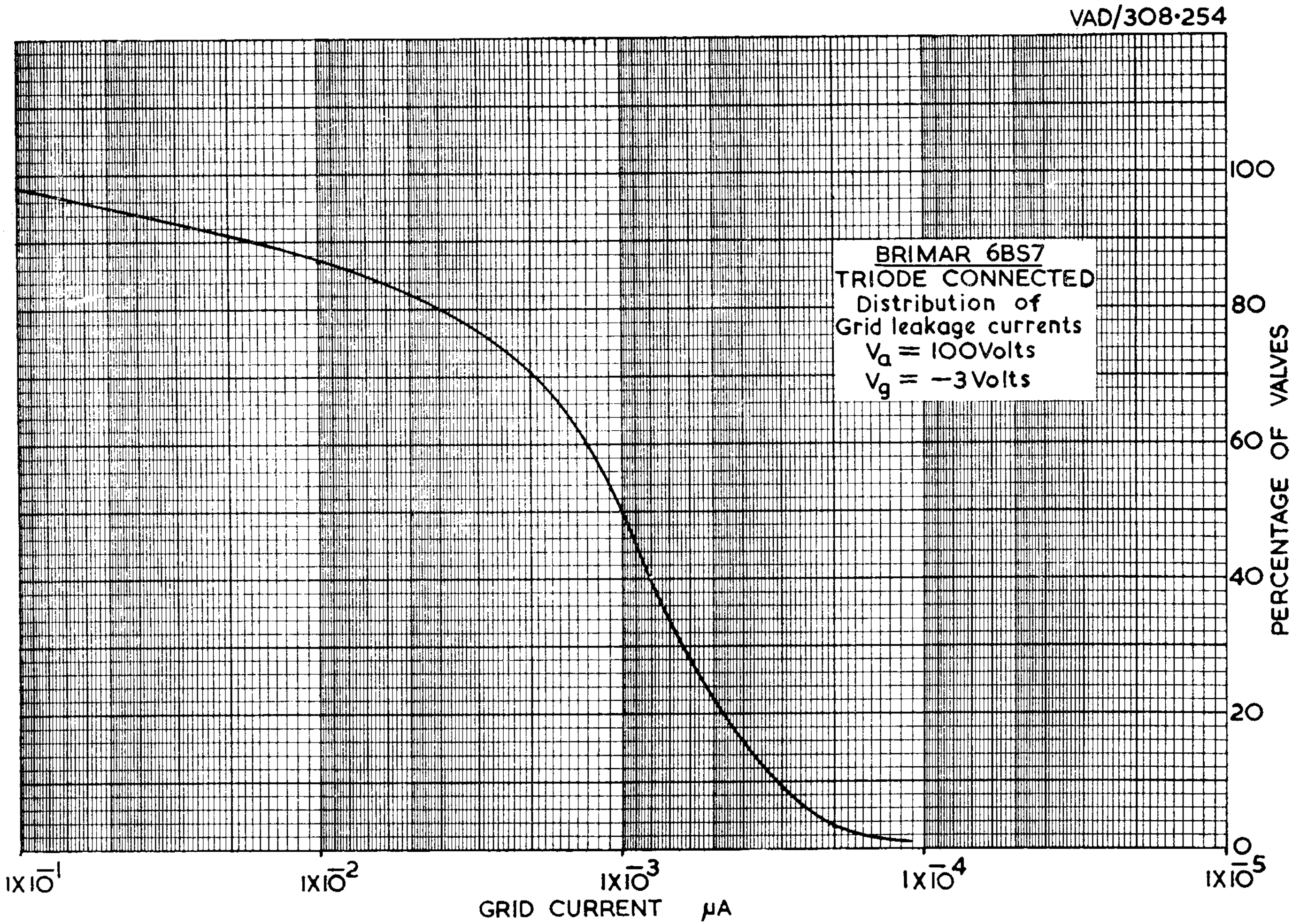
VAD/308·250
BRIMAR 6BS7
PENTODE CONNECTED
DISTRIBUTION OF HISS AS AN R.C. COUPLED AMPLIFIER
Control grid resistor $R_{g1} = 100k\Omega$
Cathode by pass condenser = 50μF
$R_a = 220k\Omega$ $R_{g2} = 1{\cdot}5M\Omega$
$R_k = 1{\cdot}5k\Omega$ $V_{a(b)} = 300V$
Bandwidth 10kc/s
100
80
60
40
20
0
PERCENTAGE OF VALVES
0
2
4
6
8
MAXIMUM HISS VOLTAGE REFERRED TO g1 μVOLTS


VAD/308-251
BRIMAR 6BS7
TRIODE CONNECTED
DISTRIBUTION OF HISS AS AN R.C.
COUPLED AMPLIFIER.
Control grid resistor=100kΩ
Cathode by-pass condenser=50μF
Ra=220kΩ. Rk=14kΩ
Va(b)=300V
Bandwidth=10kc/s
100
80
60
40
20
0
PERCENTAGE OF VALVES
0
2
4
6
8
MAXIMUM HISS VOLTAGE REFERRED TO g1 μV


BRIMAR 6BS7
PENTODE CONNECTED
Noise output referred to control grid with valve vibrated from 10-3000c/s across the major axis at a constant acceleration of 2·5g.
EQUIVALENT μV ON CONTROL GRID
120
100
80
60
40
20
0
10
100
1000
10000
FREQUENCY c/s
VAD/308·252


BRIMAR 6BS7
PENTODE CONNECTED
Noise output referred to control grid with valve vibrated from 10–3000c/s across the minor axis at a constant acceleration of 2·5g.
EQUIVALENT μV ON CONTROL GRID
120
100
80
60
40
20
0
10
100
1000
10000
FREQUENCY c/s

VAD/308·253



VAD/308·254
BRIMAR 6BS7
TRIODE CONNECTED
Distribution of
Grid leakage currents
V_a = 100Volts
V_g = −3Volts
100
80
60
40
20
0
PERCENTAGE OF VALVES
1×10^{-1}
1×10^{-2}
1×10^{-3}
1×10^{-4}
1×10^{-5}
GRID CURRENT μA

BRIMAR

RECEIVING VALVE

6BW6, 9BW6

APPLICATION REPORT VAD/507.8

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

Issued September, 1951. Reprinted January, 1952.

INTRODUCTION: The Brimar type 6BW6 is an indirectly heated beam tetrode. The heater is intended for operation in parallel with other valves in AC operated equipment. The 9BW6 is identical except that the heater is designed for use in series connected heater chains. The valve is designed for use as an output stage in receivers or in small public address amplifiers, either singly or in push-pull, and has the same characteristics and ratings as the 6V6GT.

CONSTRUCTION: The valve consists of a beam tetrode unit capable of an output of the order of 5 watts. The unit is mounted in a standard T6½ bulb and is based with a B9A (Noval) base.

This report contains characteristics of the valve and details of its use as a triode or a tetrode in push-pull and in single ended amplifiers.

CHARACTERISTICS:

Cathode:	Indirectly heated	6BW6	9BW6
	Voltage	6·3 volts*	9·0 volts (nominal)
	Current	0·45 ampere (nominal)	0·3 ampere †
	Max. Heater-Cathode potential (DC)	250 volts	250 volts

* The voltage should not vary by more than 5% of the rated value if the valve is used under Class AB2 conditions, or more than 7% if used under Class A or AB1 conditions.
† The current should not vary by more than ±5% of the rated value.

Dimensions:	Max. Overall Length	2-5/8 ins.
	Max. Diameter	7/8 in.
	Max. Seated Height	2-3/8 ins.
Base:	B9A (Noval) Nine Pin	
Basing Connections:	Pin 1 Internal Connection	
	Pin 2 Control Grid g_1	
	Pin 3 Cathode	
	Pin 4 Heater	
	Pin 5 Heater	
	Pin 6 No Connection	
	Pin 7 Anode	
	Pin 8 Screen g_2	
	Pin 9 Beam Plates	

Ratings:

TETRODE CONNECTIONS:

Max. Anode Voltage	350 volts*
Max. Screen Voltage	310 volts*
Max. Anode Dissipation	13·2 watts*
Max. Screen Dissipation	2·2 watts*
Max. Bulb Temperature °C	250*
Max. DC Anode Current	70 mA

TRIODE CONNECTIONS (Pins 7 and 8 strapped)†:

Max. (anode and screen strapped) Voltages	310*
Max. (anode and screen strapped) Dissipation	12·5 watts*
Max. DC Anode Current	75 mA

† In order to avoid parasitic oscillation pins 7 and 8 should be connected together through a 100 ohms resistor or an RF choke of about 20 microhenries.
* These ratings are absolute and must not be exceeded under any circumstances.

Capacities (approx.):*

$C_{g,a}$	0·6 pF
C_{in}	8·5 pF
C_{out}	7·5 pF
$C_{h,k}$	7·0 pF

* Measured without shield.

Mounting: The valve may be mounted in any position.

Ventilation: As this valve runs appreciably hot in operation the layout and design of equipment should be such that adequate ventilation is afforded to ensure a safe bulb temperature under all conditions. The bulb temperature of the hottest point on the surface should never exceed 250° C.

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

Anode current plotted against anode voltage for various values of grid voltage for the valve tetrode connected with a screen voltage of 250 volts (I_a/V_a) (Curve No. 307·271).

Anode current plotted against anode voltage for various values of grid voltage for the valve tetrode connected with a screen voltage of 285 volts (I_a/V_a) (Curve No. 307·272).

Anode current plotted against anode voltage for various values of grid voltage for the valve tetrode connected with a screen voltage of 225 volts (I_a/V_a) (Curve No. 307·281).

Anode current plotted against anode voltage for various values of grid voltage for the valve connected as a triode (I_a/V_a) (Curve No. 307·273).

TYPICAL OPERATION

Class A Amplifier (Single Ended):

TRIODE CONNECTION (Pins 7 and 8 strapped):

Heater Voltage	6·3	6·3	volts
Anode Voltage	250	285	volts
Grid Voltage	—13·5	—19	volts
Autobias Resistor (R_k)	300	470	ohms
Anode Impedance (r_a)	2090	2250	ohms
Anode Current (no signal)	45	40	mA
Amplification Factor (μ)	9·2	9·0	
Mutual Conductance	4·4	4·0	mA/V
Anode Load Resistor (R_a)	4000	4500	ohms
Peak AF Grid Voltage	13·5	19	volts
Total Harmonic Distortion	3·5	6·0	%
Power Output	0·75	1·35	watts

Curves are attached to this report which show the relation between power output, harmonic distortion and input signal voltage for autobias conditions at 250 volts HT (Curve No. 307·274) and at 285 volts HT (Curve No. 307·275).

Class A Amplifier (Push-Pull):

TRIODE CONNECTION (Pins 7 and 8 strapped):

Heater Voltage	6·3	6·3	volts
Anode Voltage	250	285	volts
Grid Voltage	—13·5	—19	volts
Autobias Resistor (R_k)	150	240	ohms
Anode Current (no signal)	90	78	mA
Output Load (anode-anode) ($R_{a,a}$)	4000	4500	ohms
Peak AF Grid Voltage (grid-grid)	27	38	volts
Total Harmonic Distortion	0·4	0·5	%
Power Output	1·7	3·1	watts

Note.—Values given are for two valves.

Curves are attached to this report which show the relation between power output, harmonic distortion and input signal voltage with autobias. Curve No. 307·276 at 250 volts HT and Curve No. 307·277 at 285 volts HT.

Class A Amplifier (Single Ended):

TETRODE CONNECTION:

Heater Voltage	6·3	6·3	6·3	6·3	6·3	6·3	volts
Anode Voltage	180	180	250	250	315	315	volts
Screen Voltage	180	180	250	250	225	225*	volts
Grid Voltage	—8·5	—	—12·5	—	—13	—	volts
Autobias Resistor	—	250	—	240	—	330	ohms
Anode Current	29	29	45	47	34	34	mA
Screen Current	3·0	3·0	4·5	5·0	2·2	2·2	mA
Anode Impedance (r_a)	58000	—	52000	—	77000	—	ohms
Mutual Conductance	3·7	—	4·1	—	3·75	—	mA/V
Anode Load Resistor	5500	5500	5000	5000	8500	8500	ohms
Peak AF Grid Voltage	8·5	9·0	12·5	13·5	13	13·5	volts
Total Harmonic Distortion	7·0	7·5	7·5	8	10	11·5	%
Power Output	2·0	1·7	4·5	4·5	5·2	5·0	watts

* The screen voltage, where lower than the anode voltage, should be obtained from a potentiometer across the HT line to chassis adequately by-passed to AF signals rather than by means of a series resistor to avoid fluctuation of the screen voltage as the current drives up near maximum output.

Curves are attached to this report which show the relation between power output, harmonic distortion and input signal voltage for autobias conditions at 180 volts (Curve No. 307·278), at 250 volts (Curve No. 307·279) and at 315 volts (Curve No. 307·280). Curves Nos. 307·290 and 307·291 are corresponding curves for fixed bias conditions.

Class A Amplifier (Push-Pull):

TETRODE CONNECTION:

Heater Voltage	6·3	6·3	6·3	volts
Anode Voltage	250	250	315	volts
Screen Voltage	250	250	250	volts
Grid Voltage	—12·5	—	—	volts
Autobias Resistor	—	120	125	ohms
Peak AF Grid-Grid Voltage	25	26	28	volts
No Signal Anode Current	90	94	98	mA
Max. Signal Anode Current	96	98	102	mA
No Signal Screen Current	9	9·5	8·5	mA
Max. Signal Screen Current	13·5	13·5	11·5	mA
Anode Impedance (r_a)	52000	—	—	ohms
Mutual Conductance	4·1	—	—	mA/V
Output Load (anode to anode)	10000	10000	10000	ohms
Total Harmonic Distortion	2	2·5	2·5	%
Power Output	9	9	12·5	watts

Note.—Values given are for two valves.

Curves are attached to this report which show the relation between power output, distortion and input signal for the 250 volt autobias conditions (Curve No. 307·282), for fixed bias (Curve No. 207·283) and for the 315 volt condition with autobias (Curve No. 307·284).

Class ABI Amplifier (Push-Pull):

TETRODE CONNECTION:

Heater Voltage	6·3	6·3	6·3	6·3	volts
Anode Voltage	250	250	285	285	volts
Screen Voltage	250	250	285	285	volts
Grid Voltage	—15	—	—19	—	volts
Autobias Resistor	—	200	—	260	ohms
Peak AF Grid-Grid Voltage	30	34	38	45	volts
No Signal Anode Current	70	70	70	70	mA
Max. Signal Anode Current	80	74	94	78·5	mA
No Signal Screen Current	5	5	4	4	mA
Max. Signal Screen Current	11·5	11·5	11·5	10	mA
Load Resistance (anode-anode)	10000	10000	8000	8000	ohms
Total Harmonic Distortion	3	3·5	1·8	1	%
Power Output	10	10	13	12	watts

Note.—Values given are for two valves.

Curves are attached to this report which show the relation between power output, distortion and input signal voltage for the 250 volt conditions, Curve No. 307·285 for fixed bias and Curve No. 307·286 for automatic bias. For the 285 volt condition there are Curves No. 307·287 for fixed bias and No. 307·288 for automatic bias.

Class AB2 Amplifier (Push-Pull):

TETRODE CONNECTION:

Heater Voltage	6·3	volts
Anode Voltage	315	volts
Screen Voltage	285	volts
Grid Voltage	—19	volts
Peak AF Grid-Grid Voltage	80	volts
No Signal Anode Current	70	mA
Max. Signal Anode Current	155	mA
No Signal Screen Current	4	mA
Max. Signal Screen Current	16	mA
Peak Grid Input Power	400	Milliwatts
Load Resistor (anode-anode)	5000	ohms
Total Harmonic Distortion	7	%
Power Output	30	watts

Note.—Values given are for two valves.

It is essential for Class AB2 operation that the regulation of the anode, screen and grid bias supplies is such that the voltages remain constant within 5% between no signal and maximum signal conditions. The driver stage should be capable of supplying the grids of the two valves with the specified peak voltages with low distortion. The effective resistance per grid circuit represented by the driver valve and/or transformer should not exceed 500 ohms and the effective impedance represented by leakage inductance or equivalent at the highest desired response frequency should not exceed 700 ohms.

A curve (No. 307·289) is attached to this report which shows the relation between power output, distortion and input signal voltage for the above conditions.

GENERAL RECOMMENDATIONS:

Audio Frequencies: Due to the relatively high slope of this valve, trouble may be experienced due to parasitic oscillation, and it is advised that a resistor of 100 ohms is wired in series with the anode, directly connected to the valve holder contact.

This resistor should be reduced to 47 ohms in the case of Class AB2 operation.

A series grid resistor may also be employed, if necessary, wired directly to the valve holder grid contact, but the value must be carefully chosen bearing the frequency response in mind. Such a resistor should never exceed 100,000 ohms for Class A operation, and should not be employed for Class AB2 operation.

The type of input coupling used should not introduce too much resistance into the grid circuit. It is preferable that such resistance does not exceed 100,000 ohms except in the case of Class A operation under automatic bias conditions where the value may be as high as 500,000 ohms.

Radio Frequencies: Whilst these valves are not primarily intended for operation as an oscillator or as a frequency multiplier they may be used for such purpose up to a maximum frequency of 160 Mc/s.

The ratings given on page 2 must under no circumstances be exceeded nor may the DC grid current at any time exceed 3 mA.

It is preferable that the screen supply voltage should not be obtained via a series dropping resistor, and the DC bias should be obtained from a fixed bias or from a combination of grid leak bias and a cathode automatic bias resistor.

The bias required as a Class C frequency multiplier is of the order of —80 volts and the output with normal circuit practice is adequate at second or third harmonic to drive an RF amplifier employing valves such as the 807 (5B/250A) or 5763.

When these valves are used as crystal oscillators in a Tri-tet circuit care should be exercised to ensure a safe crystal current if the screen voltage is 180 volts or higher.

If this valve is used as a Class "B" or Class "C" RF amplifier neutralisation will normally be necessary at the higher frequencies. Power amplifier operation is not recommended above 100 Mc/s due to the relatively high input drive required. At this and higher frequencies it is more economical to use the valve as a frequency multiplier.

Keying should not be achieved by disconnection of the cathode unless a resistor of not more than 100,000 ohms is permanently connected between cathode and chassis earth.

Under no circumstances should the anode tank circuit of a Class "B" or "C" amplifier be tuned through resonance with the aerial or succeeding valve load disconnected. Such procedure causes a violent drop in the anode current and a corresponding increase in screen current which may damage the screen, together with a very high voltage between anode and other electrodes which is liable to break down the insulation of the button base.

TYPICAL OPERATION

RF Doubler. Continuous ratings as a doubler without modulation:

DC Anode Voltage	250	300	volts
DC Screen Voltage	250	250	volts
DC Screen Series Resistor	—	9100	ohms
DC Grid Voltage	—60	—70	volts
DC Grid Resistor	18000	21000	ohms
DC Cathode Resistor	100	100	ohms
Peak RF Grid Voltage	100	100	volts
DC Anode Current	52	46	mA
DC Screen Current	5·0	5·5	mA
DC Grid Current (approximately)	3·0	3·0	mA
Driving Power (approximately)	0·3	0·3	watt
Power Output	5·0	5·5	watts*

* Measured with typical tank coil doubling from 7—14 Mc/s.

RF Trebler. Continuous ratings as a trebler without modulation:

DC Anode Voltage	300	volts
DC Screen Voltage	250	volts
DC Screen Series Resistor	12500	ohms
DC Grid Voltage	—94	volts
DC Cathode Resistor	500	ohms
DC Grid Resistor	23000	ohms
Peak RF Grid Voltage	150	volts
DC Anode Current	46	mA
DC Screen Current	4	mA
DC Grid Current (approximately)	3	mA
Driving Power (approximately)	0·45	watt
Power Output	2·5	watts*

* Measured with typical tank coil trebling from 7—21 Mc/s.

Frame Time Base: A circuit showing the valve used for television frame time base output is given on VAD/307·55. The valve is triode connected, as this enables adequate linearity to be obtained without great difficulty. Tetrode connection has the advantage of greater sensitivity and power output, but much of this has to be sacrificed in the negative feed back necessary to linearise the trace.

The HT current consumption is between 25 and 30 mA when the time base is operated from a 250 volt HT rail. The output is adequate for cathode ray tubes with scanning angles up to 55°. For wide angle deflections of 65° or more the circuit may be operated from an HT rail of 300 volts; the bias resistor R11 should then be increased to 1000 ohms. Suitable wide angle scanning components and output transformer must be used.

In the circuit shown certain of the component values may require modification to suit individual applications.

R3, the charging resistor to the blocking oscillator, affects the output, a lower value giving greater output but poorer linearity.

R7 affects mainly the bottom of the picture, a lower value stretching out this region.

R11 should deliver the correct bias so that the 6BW6 operates in the centre of the linear part of its characteristic. Too high a bias causes compression of the end of the scan, too low a bias compression of the commencement as the valve draws grid current on the positive peaks.

R9, the linearity control closes the top of the picture as it is reduced in value.

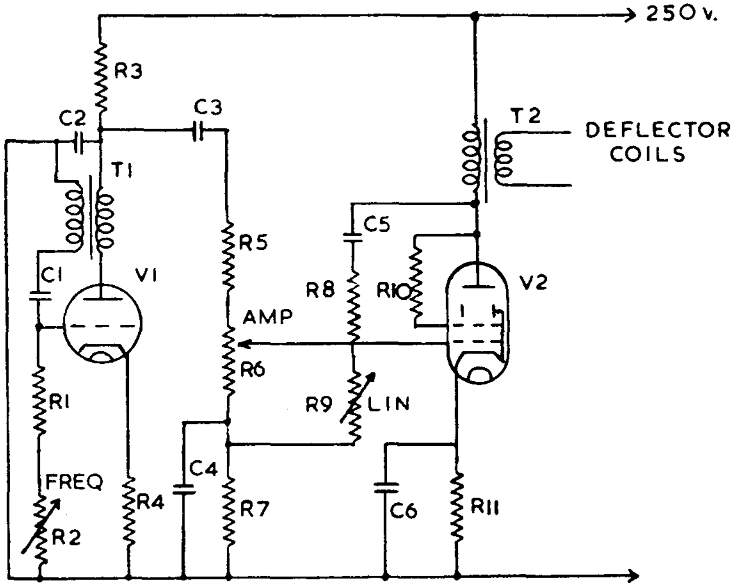
C4 influences the feedback circuit, stretching the top of the picture as it is increased.

C5 affects both top and bottom of the picture, too high a value causing stretching of the top and cramping of the bottom.

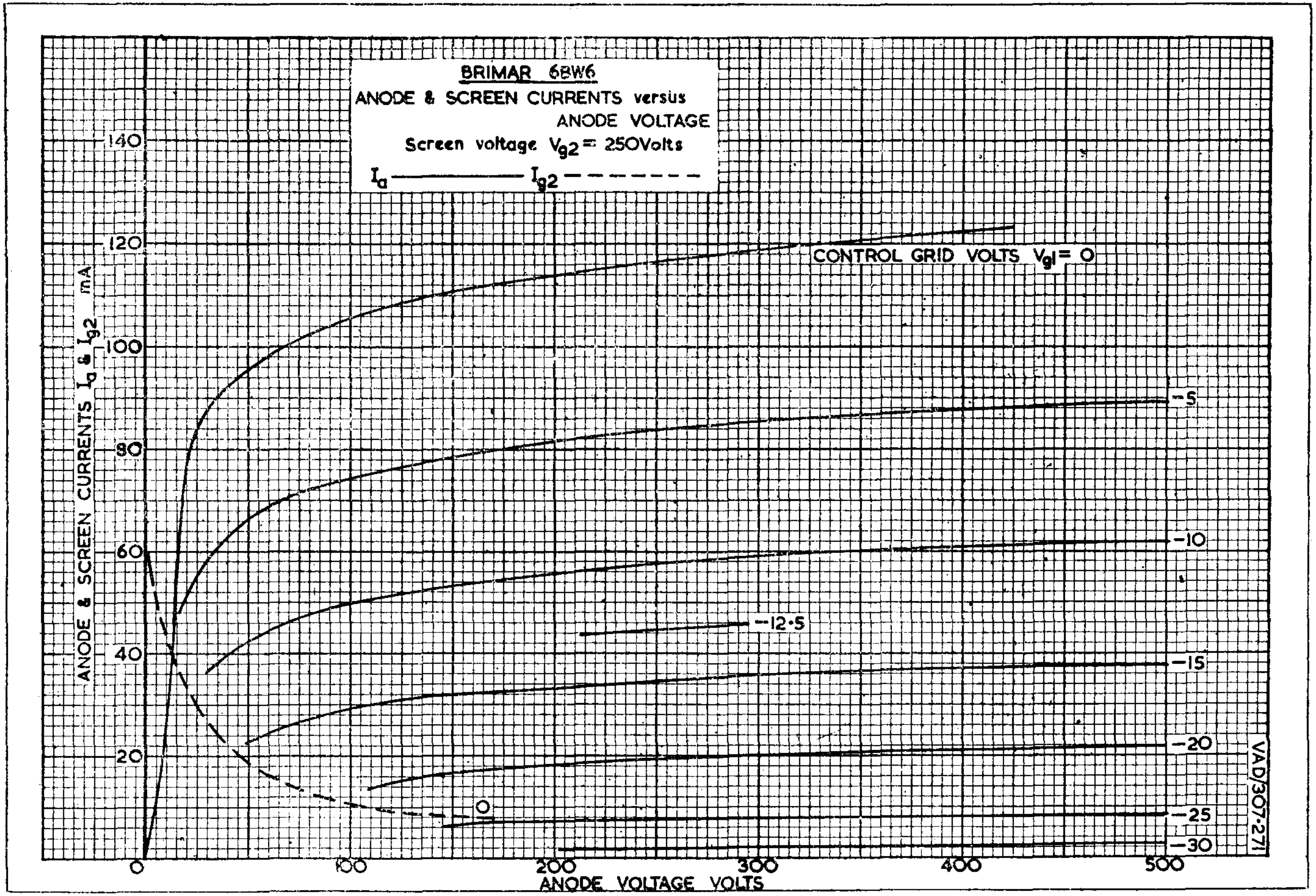
Synchronising pulses may be fed either to the grid or to the anode of the blocking oscillator, depending whether their polarity is positive or negative.

BRIMAR 6BW6

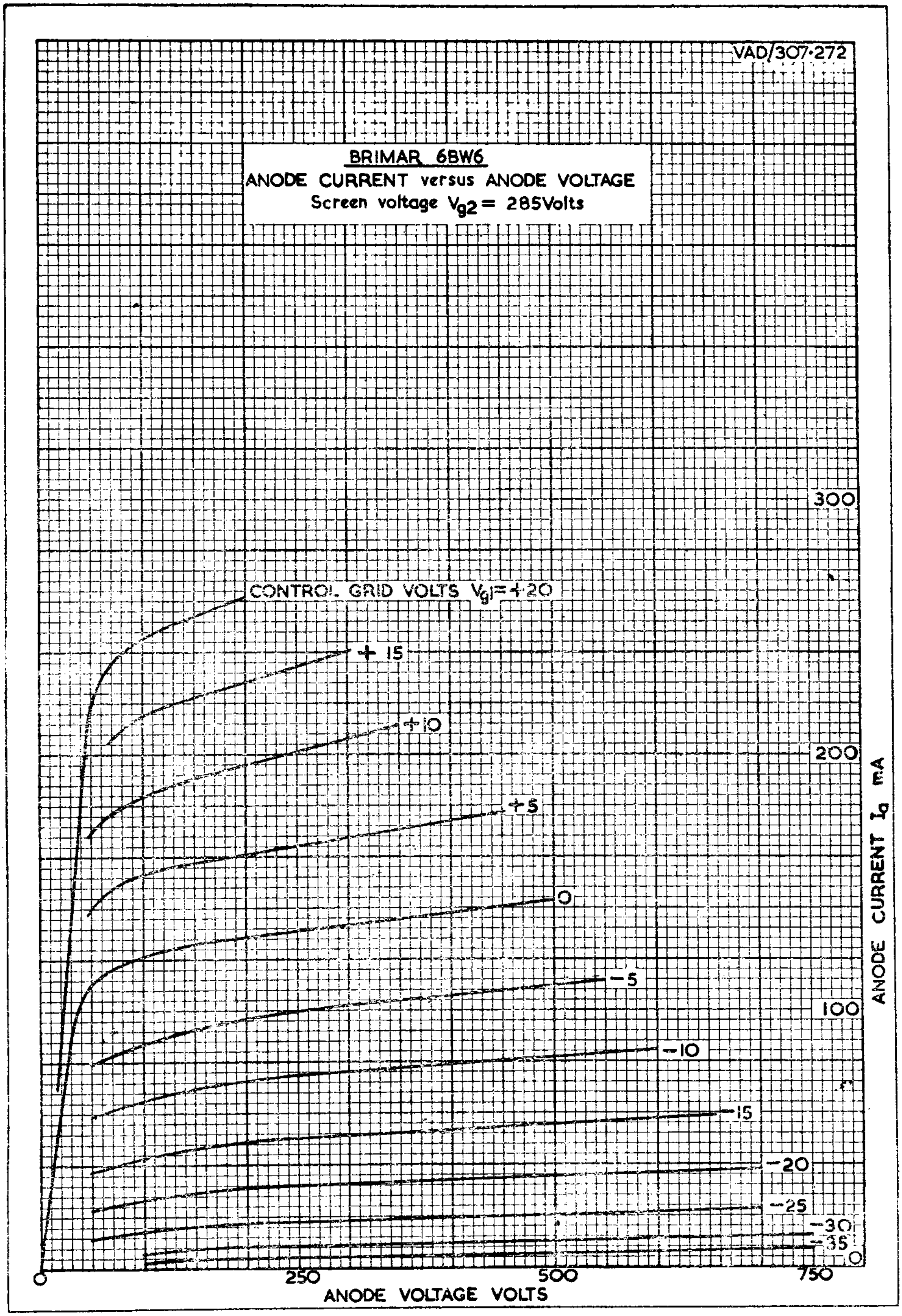
FRAME TIME BASE

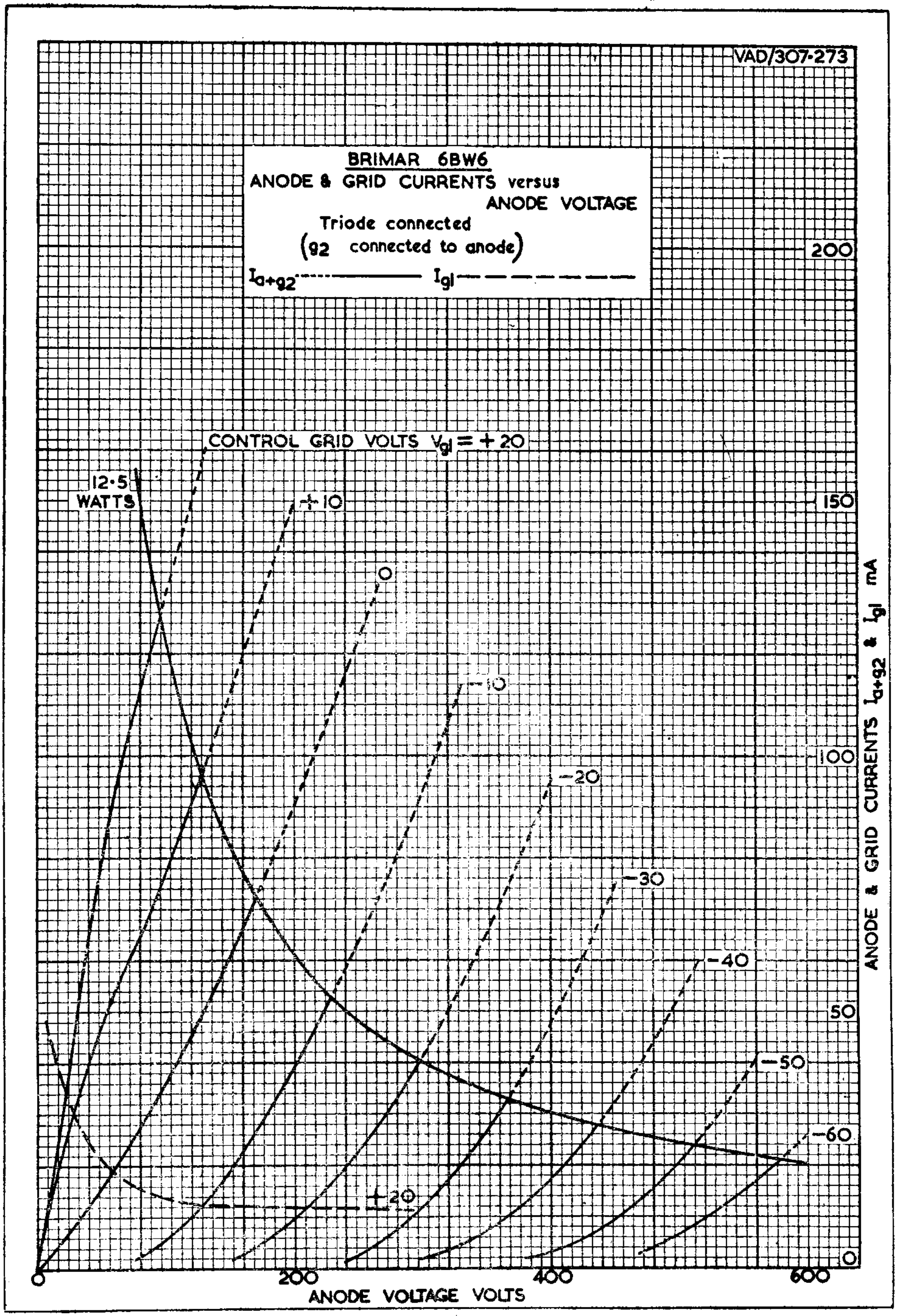


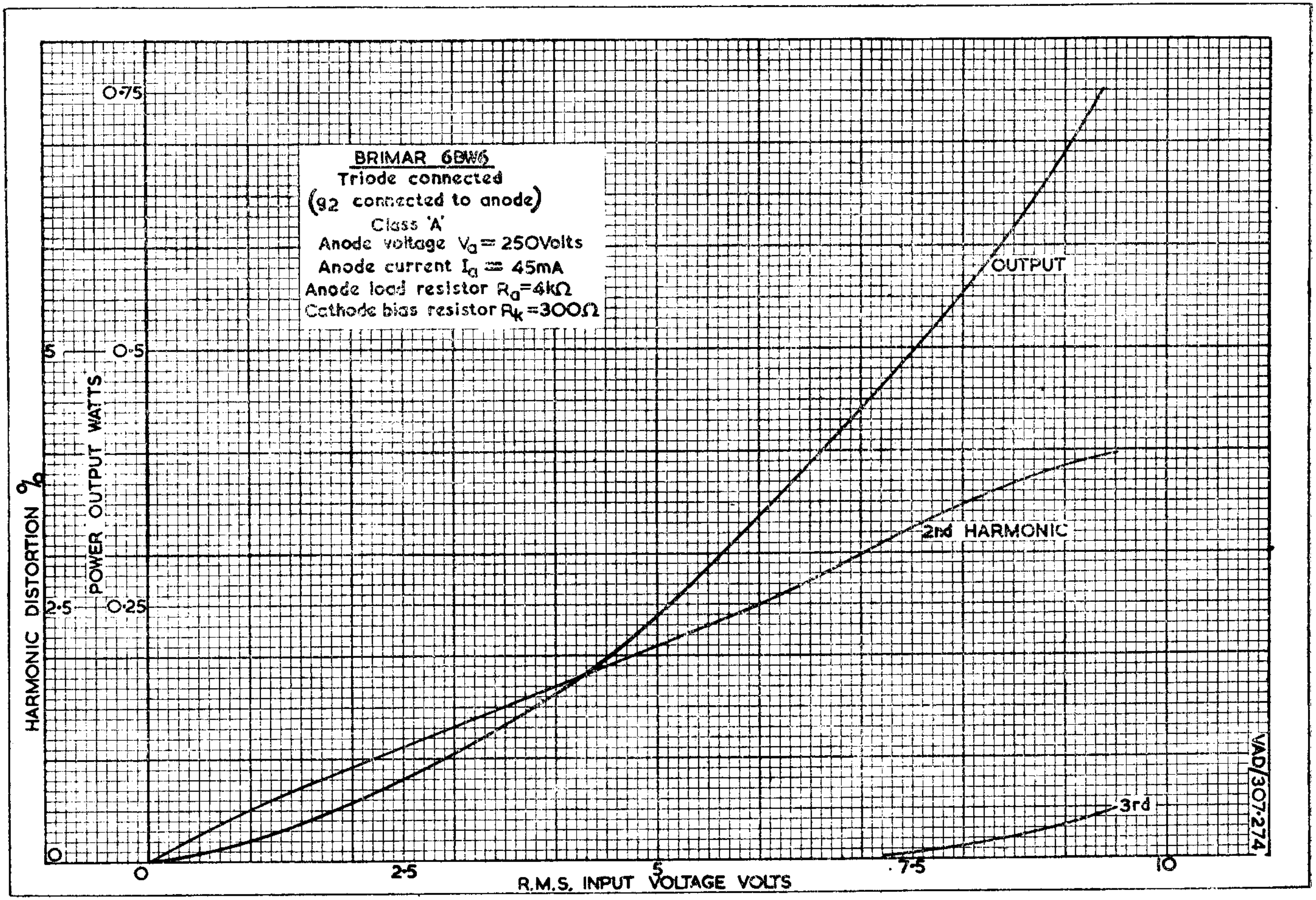
R_1	47 k	C_1	0·5
R_2	100 k var.	C_2	0·1
R_3	470 k	C_3	0·1
R_4	220	C_4	0·005
R_5	330 k	C_5	0·01
R_6	1 M pot.	C_6	30 Electrolytic
R_7	470 k	T_1	Frame Blocking Oscillator Transformer. Plessey CP92553
R_9	250 k var.	T_2	Frame Output Transformer. Plessey CP71956/1
R_{10}	100		Deflector Coils, Plessey CP72419
R_{11}	680		
V_1	6C4 or 1/2 12AU7	V_2	6BW6



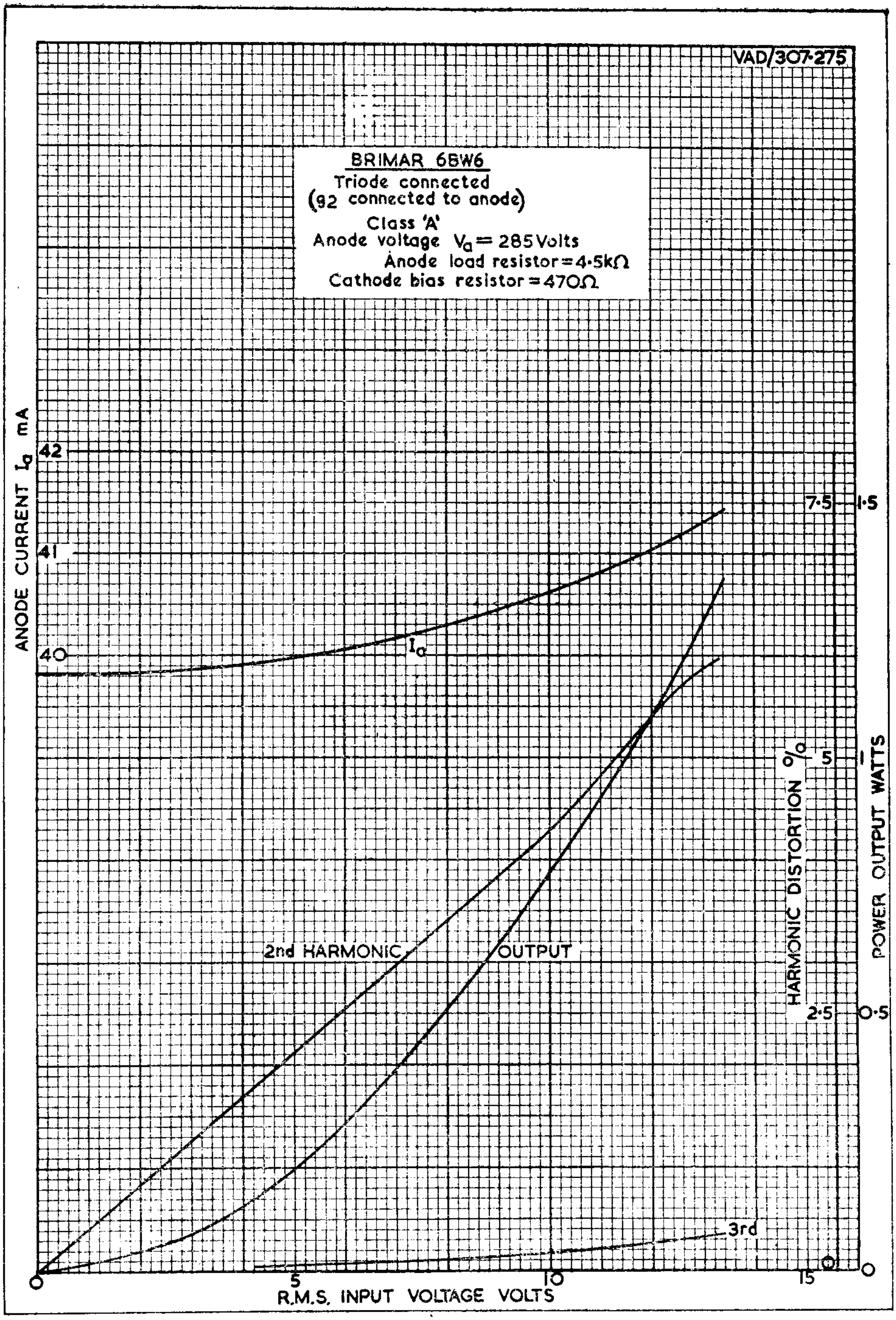
BRIMAR 6BW6
ANODE & SCREEN CURRENTS versus
ANODE VOLTAGE
Screen voltage V_{g2} = 250Volts
I_a ———— I_{g2} - - - - -
CONTROL GRID VOLTS V_{g1} = 0
-5
-10
-12·5
-15
-20
-25
-30
0
ANODE & SCREEN CURRENTS I_a & I_{g2} mA
140
120
100
80
60
40
20
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VAD/307·271


VAD/307·272
BRIMAR 6BW6
ANODE CURRENT versus ANODE VOLTAGE
Screen voltage V_{g2} = 285 Volts
CONTROL GRID VOLTS V_{g1} = +20
+15
+10
+5
0
−5
−10
−15
−20
−25
−30
−35
300
200
100
0
250
500
750
ANODE VOLTAGE VOLTS
ANODE CURRENT I_a mA

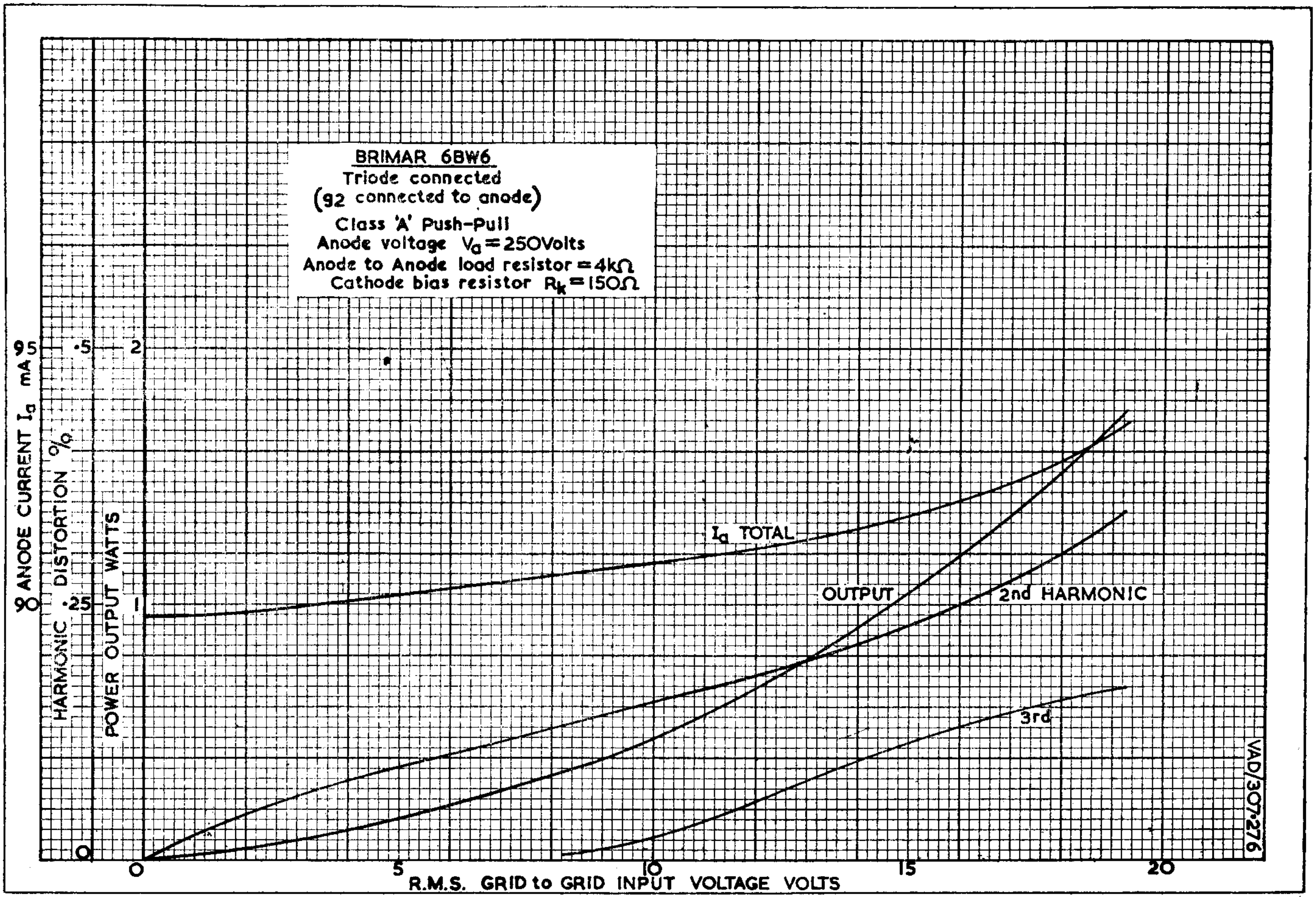

VAD/307-273
BRIMAR 6BW6
ANODE & GRID CURRENTS versus ANODE VOLTAGE
Triode connected
(g2 connected to anode)
Ia+g2 ———— Ig1 — — — —
CONTROL GRID VOLTS Vg1 = +20
12·5 WATTS
+10
0
−10
−20
−30
−40
−50
−60
+20
200
150
100
50
0
200
400
600
ANODE VOLTAGE VOLTS
ANODE & GRID CURRENTS Ia+g2 & Ig1 mA

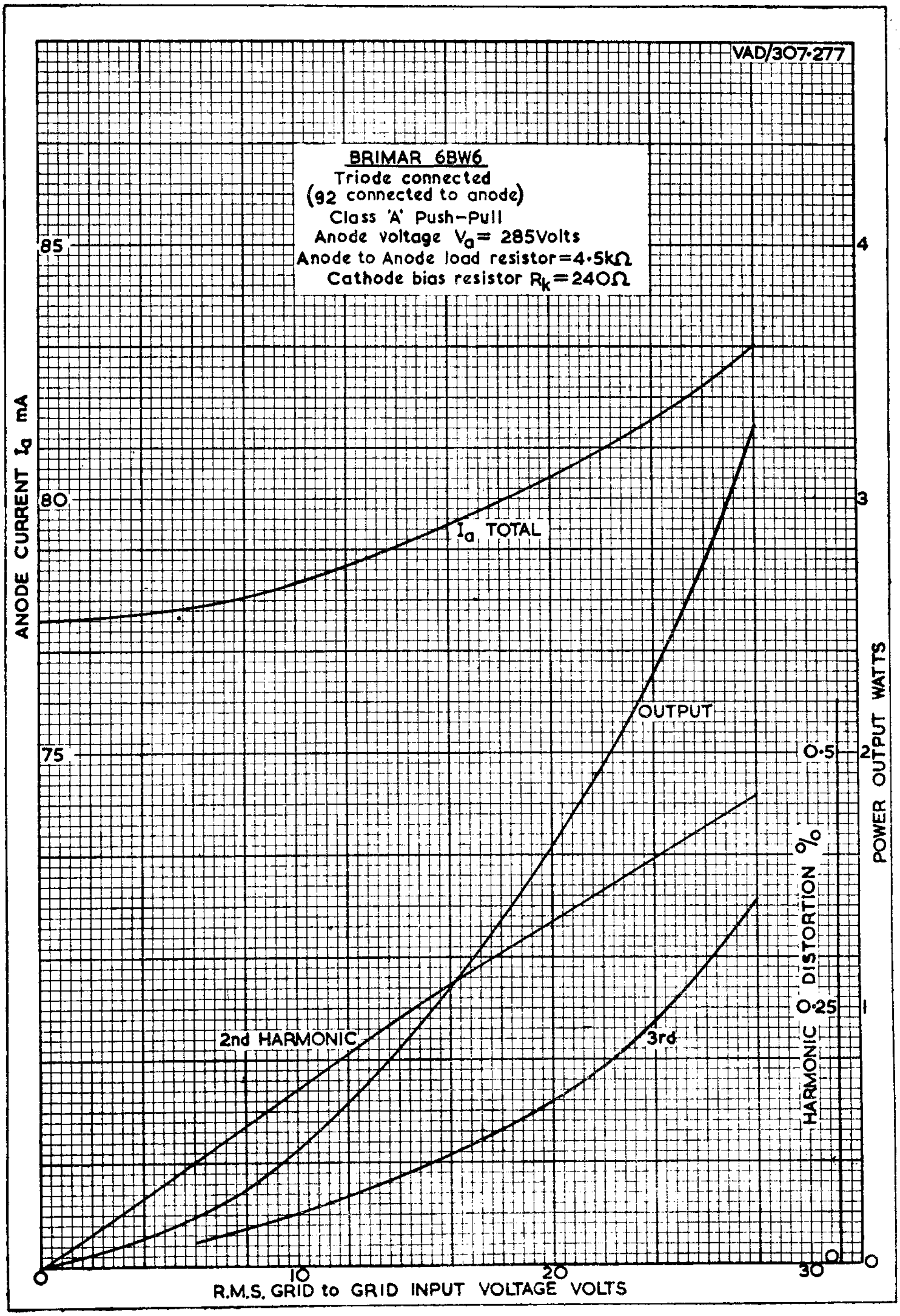


BRIMAR 6BW6
Triode connected
(g2 connected to anode)
Class 'A'
Anode voltage Va = 250Volts
Anode current Ia = 45mA
Anode load resistor Ra=4kΩ
Cathode bias resistor Rk =300Ω
OUTPUT
2nd HARMONIC
3rd
0·75
0·5
0·25
5
2·5
0
2·5
5
7·5
10
HARMONIC DISTORTION %
POWER OUTPUT WATTS
R.M.S. INPUT VOLTAGE VOLTS
VAD/307·274

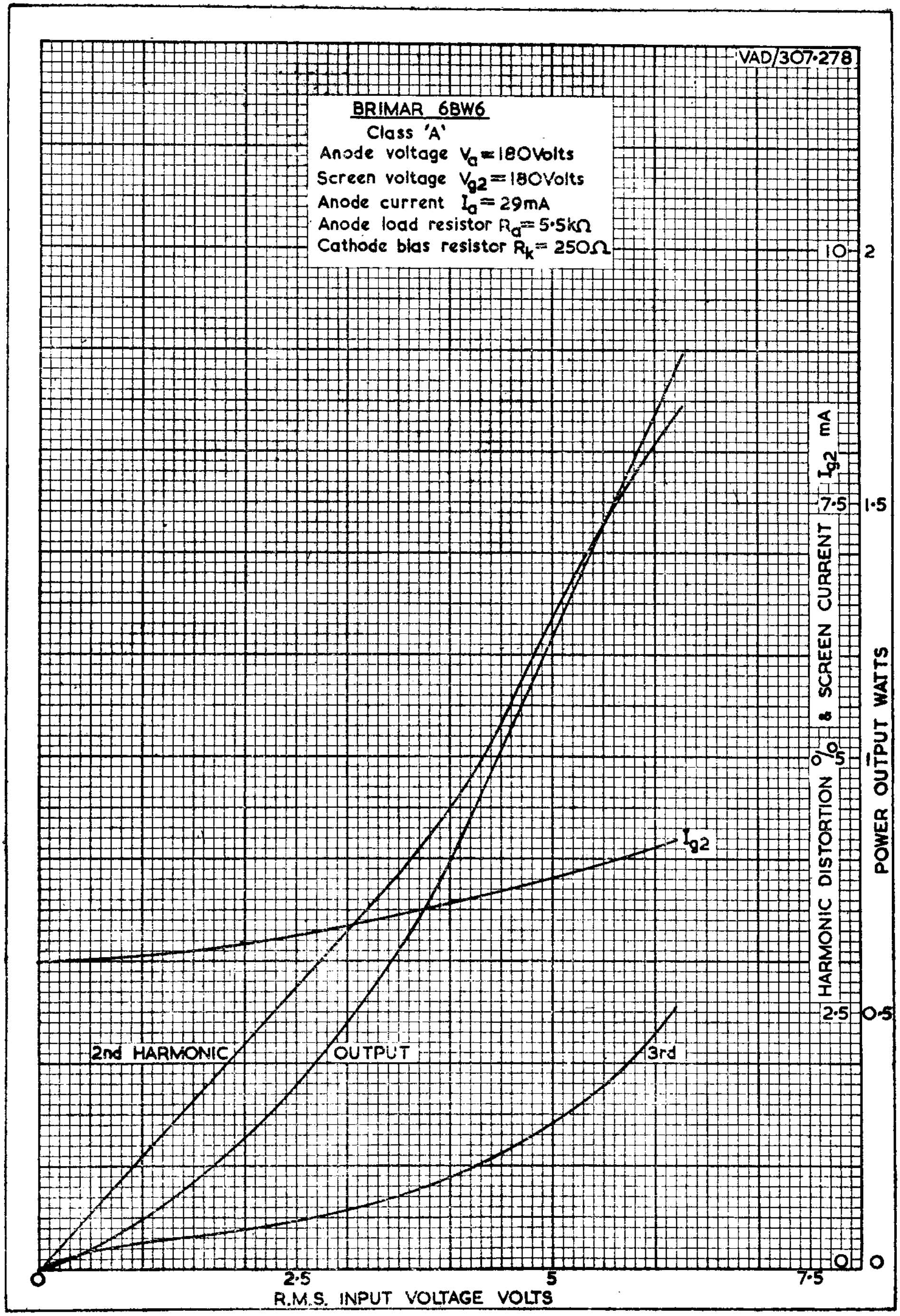


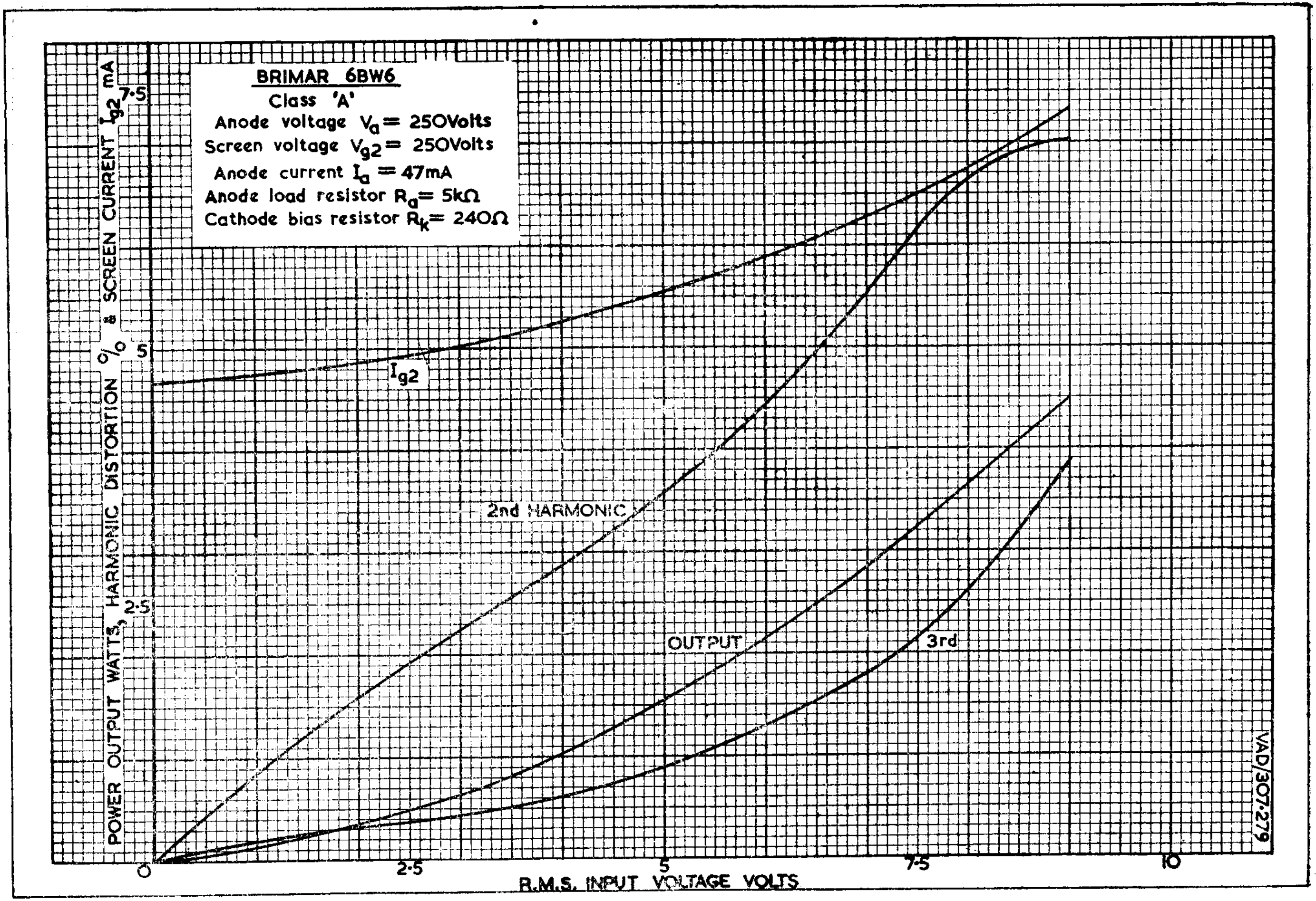
VAD/307-275
BRIMAR 6BW6
Triode connected
(g2 connected to anode)
Class 'A'
Anode voltage Va = 285 Volts
Anode load resistor = 4·5kΩ
Cathode bias resistor = 470Ω
ANODE CURRENT Ia mA
42
41
40
Ia
2nd HARMONIC
OUTPUT
3rd
HARMONIC DISTORTION %
POWER OUTPUT WATTS
7·5
1·5
5
1
2·5
0·5
0
0
5
10
15
R.M.S. INPUT VOLTAGE VOLTS


BRIMAR 6BW6
Triode connected
(g2 connected to anode)
Class 'A' Push-Pull
Anode voltage Va = 250 Volts
Anode to Anode load resistor = 4kΩ
Cathode bias resistor Rk = 150Ω
Ia TOTAL
OUTPUT
2nd HARMONIC
3rd
ANODE CURRENT Ia mA
HARMONIC DISTORTION %
POWER OUTPUT WATTS
R.M.S. GRID to GRID INPUT VOLTAGE VOLTS
VAD/307·276
95
90
·5
·25
O
2
1
0
5
10
15
20

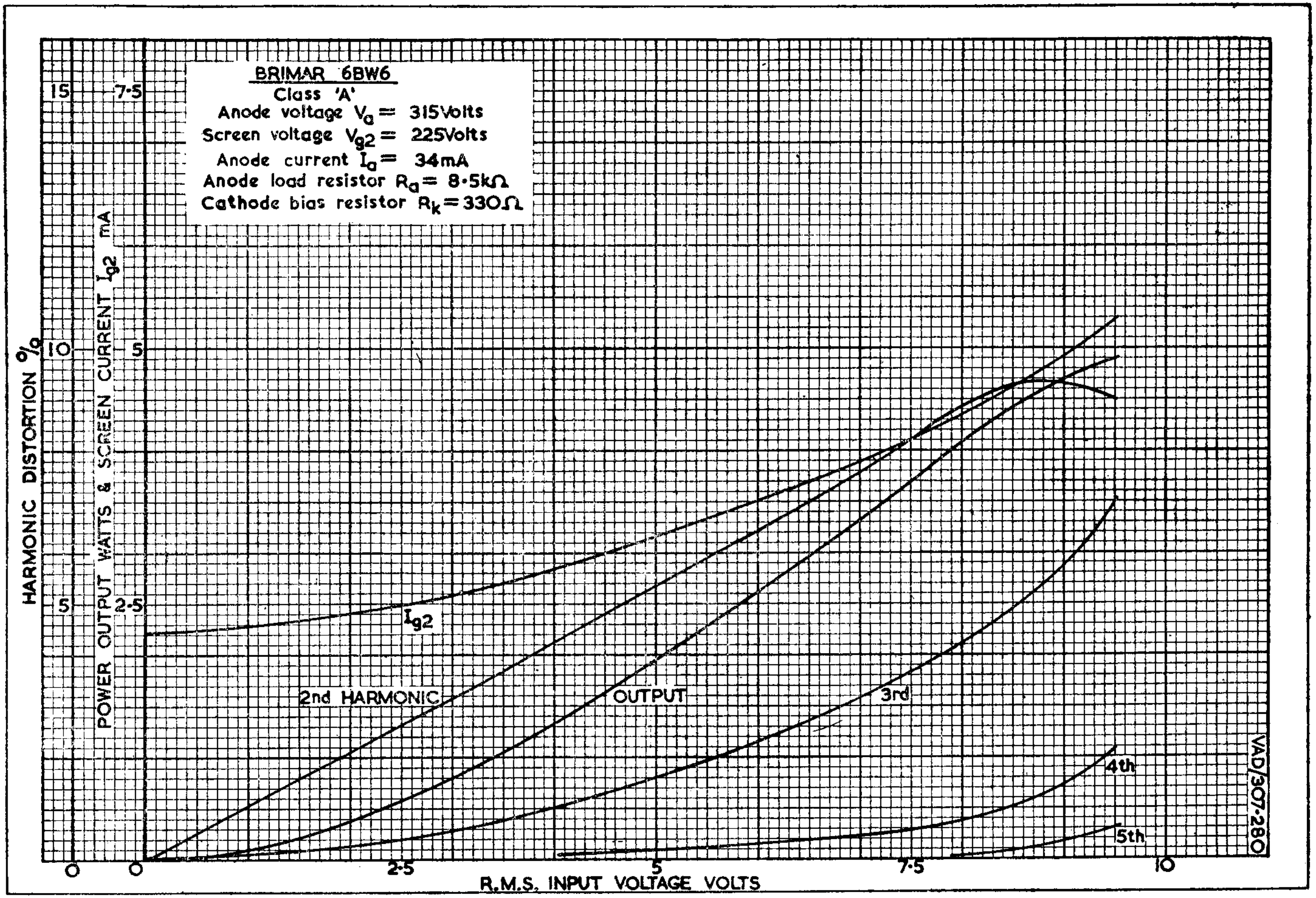


VAD/307·277
BRIMAR 6BW6
Triode connected
(g2 connected to anode)
Class 'A' Push-Pull
Anode voltage Va= 285Volts
Anode to Anode load resistor=4·5kΩ
Cathode bias resistor Rk=240Ω
ANODE CURRENT Ia mA
85
80
75
4
3
2
1
0
0·5
0·25
0
Ia TOTAL
OUTPUT
2nd HARMONIC
3rd
HARMONIC DISTORTION %
POWER OUTPUT WATTS
0
10
20
30
R.M.S. GRID to GRID INPUT VOLTAGE VOLTS

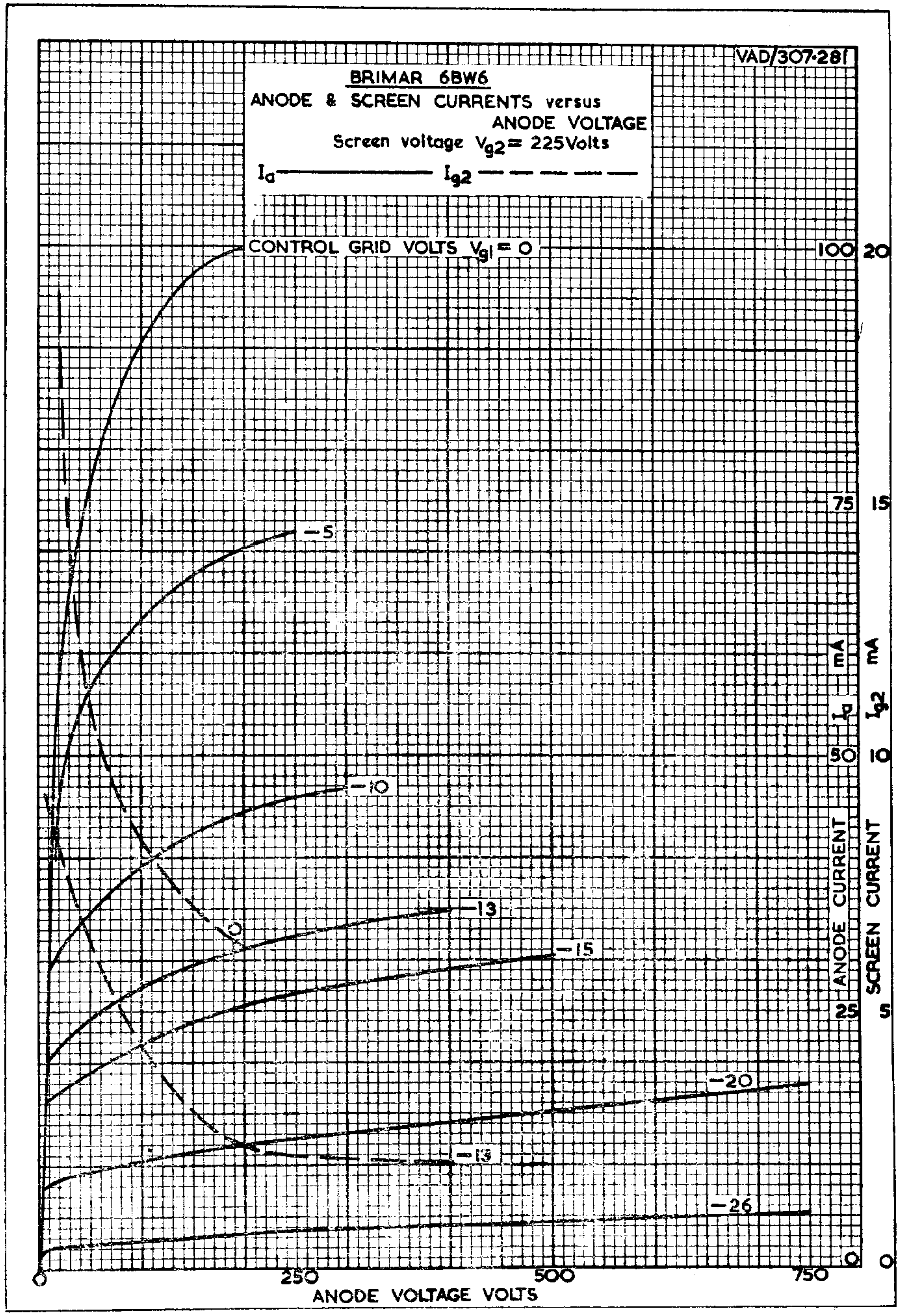

VAD/307·278
BRIMAR 6BW6
Class 'A'
Anode voltage V_a = 180 Volts
Screen voltage V_{g2} = 180 Volts
Anode current I_a = 29mA
Anode load resistor R_a = 5·5kΩ
Cathode bias resistor R_k = 250Ω
I_{g2}
2nd HARMONIC
OUTPUT
3rd
HARMONIC DISTORTION % & SCREEN CURRENT I_{g2} mA
POWER OUTPUT WATTS
R.M.S. INPUT VOLTAGE VOLTS
0
2·5
5
7·5
10
2
1·5
0·5



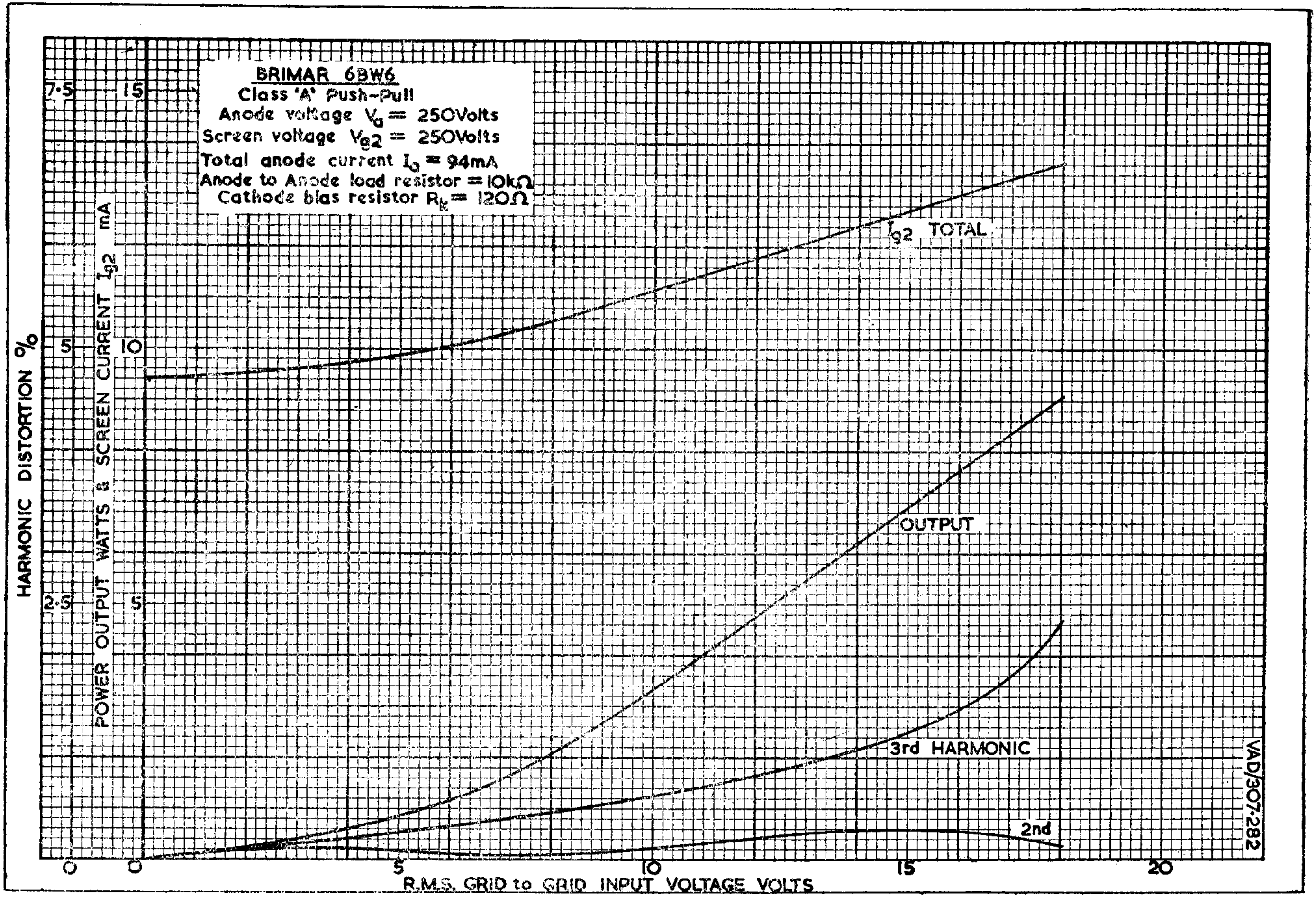
BRIMAR 6BW6
Class 'A'
Anode voltage V_a = 250Volts
Screen voltage V_{g2} = 250Volts
Anode current I_a = 47mA
Anode load resistor R_a = 5kΩ
Cathode bias resistor R_k = 240Ω
I_{g2}
2nd HARMONIC
OUTPUT
3rd
POWER OUTPUT WATTS, HARMONIC DISTORTION % & SCREEN CURRENT I_{g2} mA
7·5
5
2·5
0
2·5
5
7·5
10
R.M.S. INPUT VOLTAGE VOLTS
VAD/307·279

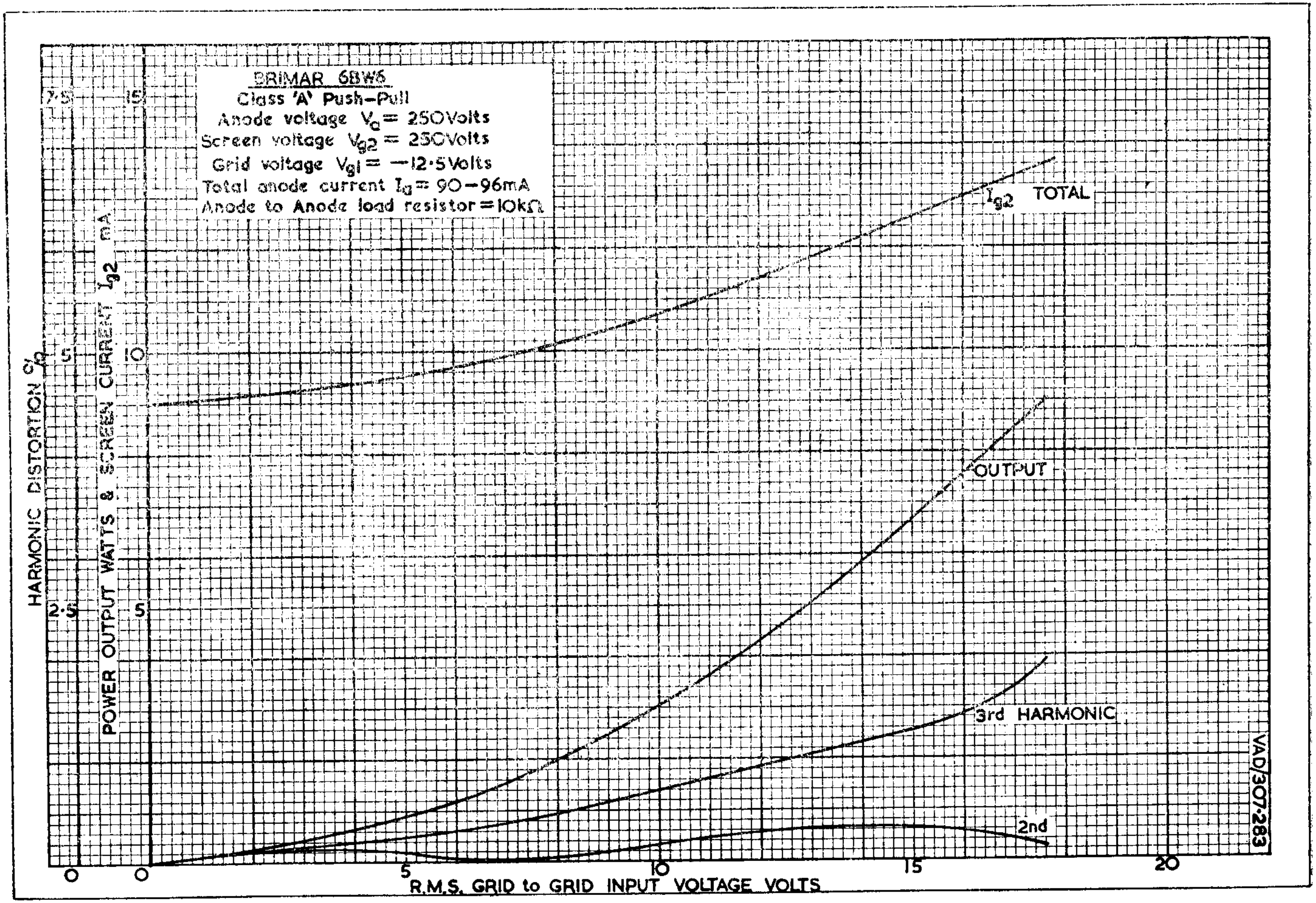


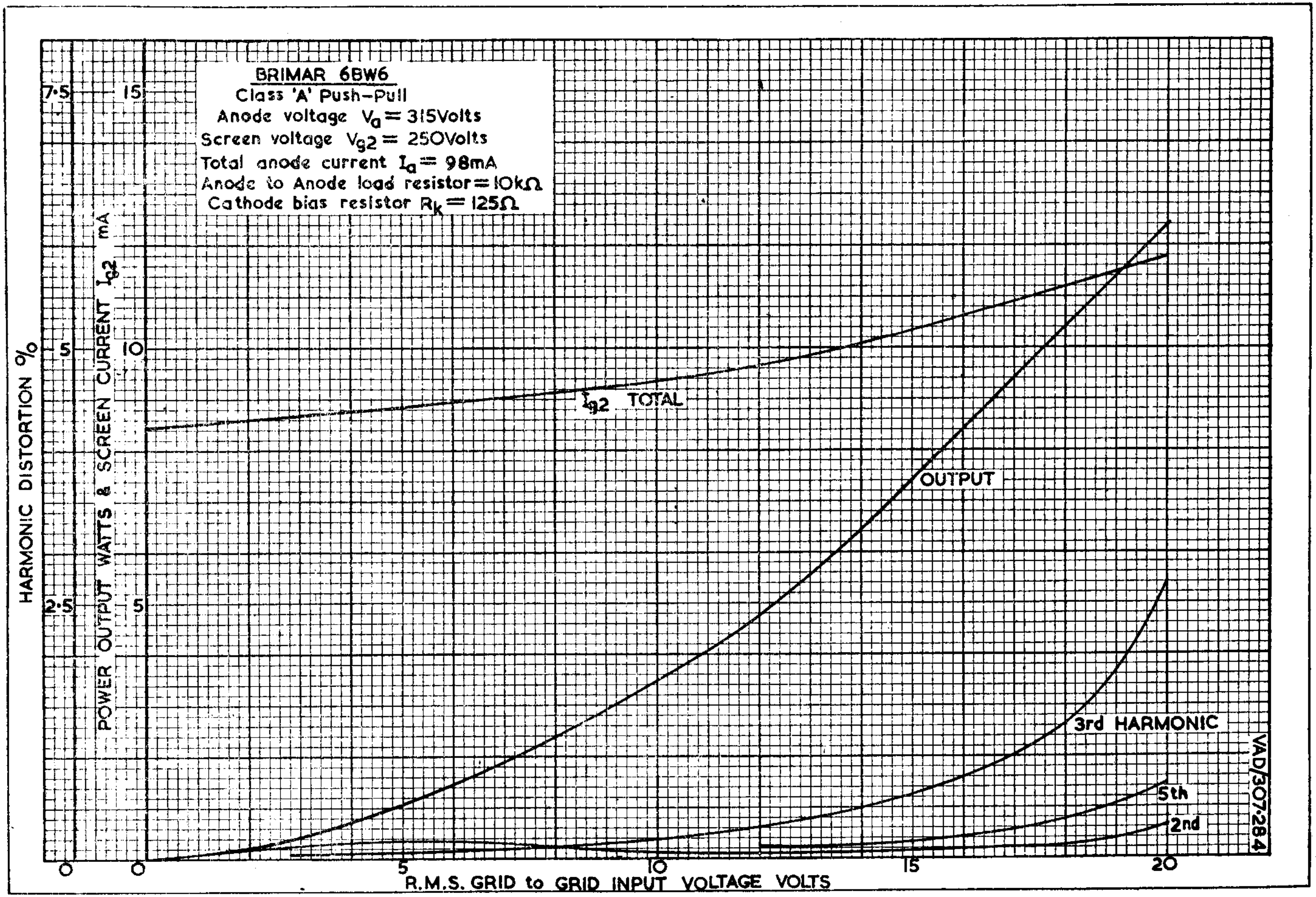
BRIMAR 6BW6
Class 'A'
Anode voltage V_a = 315Volts
Screen voltage V_{g2} = 225Volts
Anode current I_a = 34mA
Anode load resistor R_a = 8·5kΩ
Cathode bias resistor R_k = 330Ω
HARMONIC DISTORTION %
POWER OUTPUT WATTS & SCREEN CURRENT I_{g2} mA
15
7·5
10
5
5
2·5
0
0
I_{g2}
2nd HARMONIC
OUTPUT
3rd
4th
5th
2·5
5
7·5
10
R.M.S. INPUT VOLTAGE VOLTS
VAD/307-280

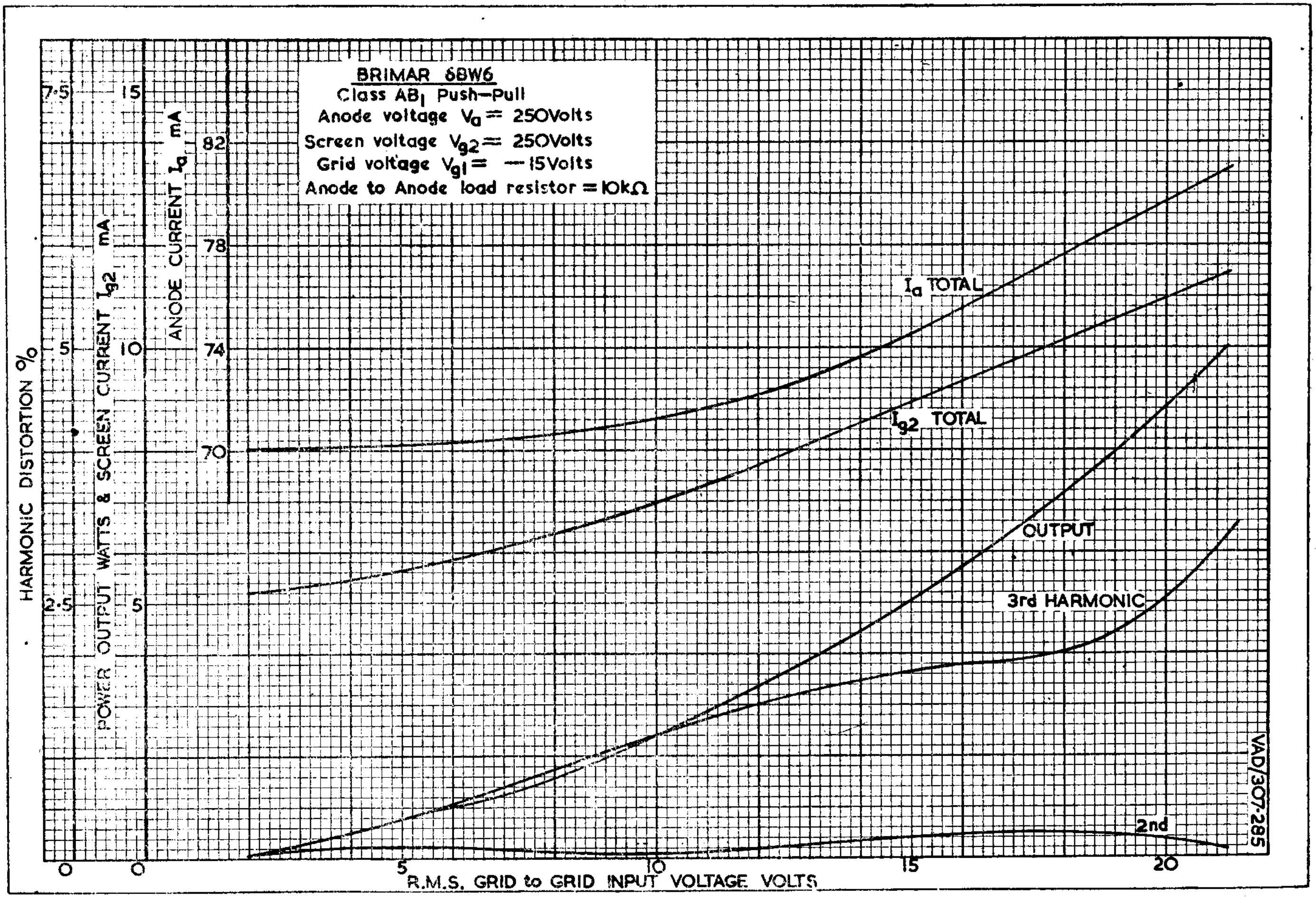


VAD/307·281
BRIMAR 6BW6
ANODE & SCREEN CURRENTS versus ANODE VOLTAGE
Screen voltage Vg2 = 225 Volts
Ia ——— Ig2 - - - - -
CONTROL GRID VOLTS Vg1 = 0
-5
-10
-13
-15
-20
-26
0
-13
100 20
75 15
50 10
25 5
0 0
ANODE CURRENT Ia mA
SCREEN CURRENT Ig2 mA
0
250
500
750
ANODE VOLTAGE VOLTS

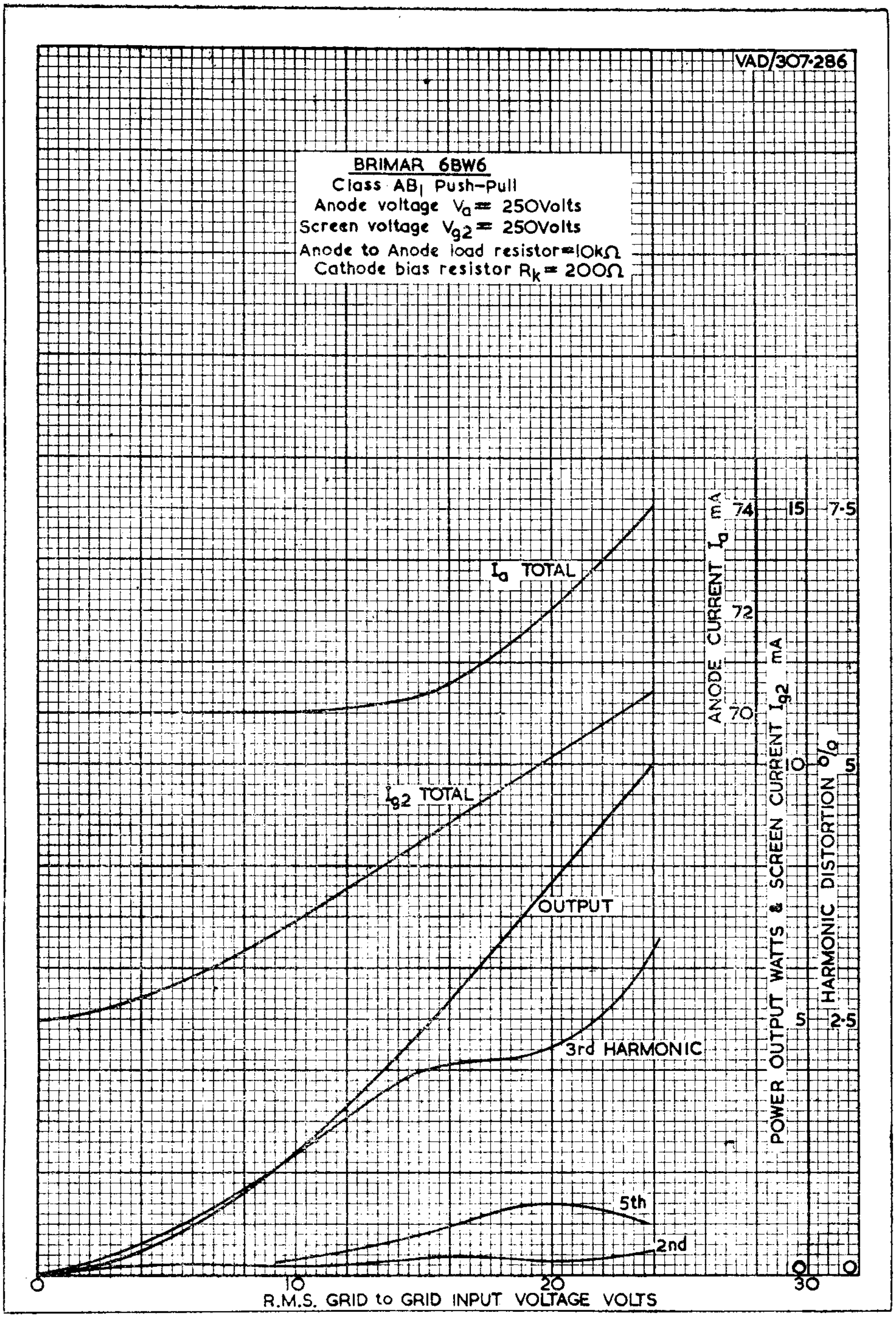

BRIMAR 6BW6
Class 'A' Push-Pull
Anode voltage Va = 250Volts
Screen voltage Vg2 = 250Volts
Total anode current Ia = 94mA
Anode to Anode load resistor = 10kΩ
Cathode bias resistor Rk = 120Ω
Ig2 TOTAL
OUTPUT
3rd HARMONIC
2nd
HARMONIC DISTORTION %
POWER OUTPUT WATTS & SCREEN CURRENT Ig2 mA
R.M.S. GRID to GRID INPUT VOLTAGE VOLTS
VAD/307·282
0
2·5
5
7·5
0
5
10
15
0
5
10
15
20

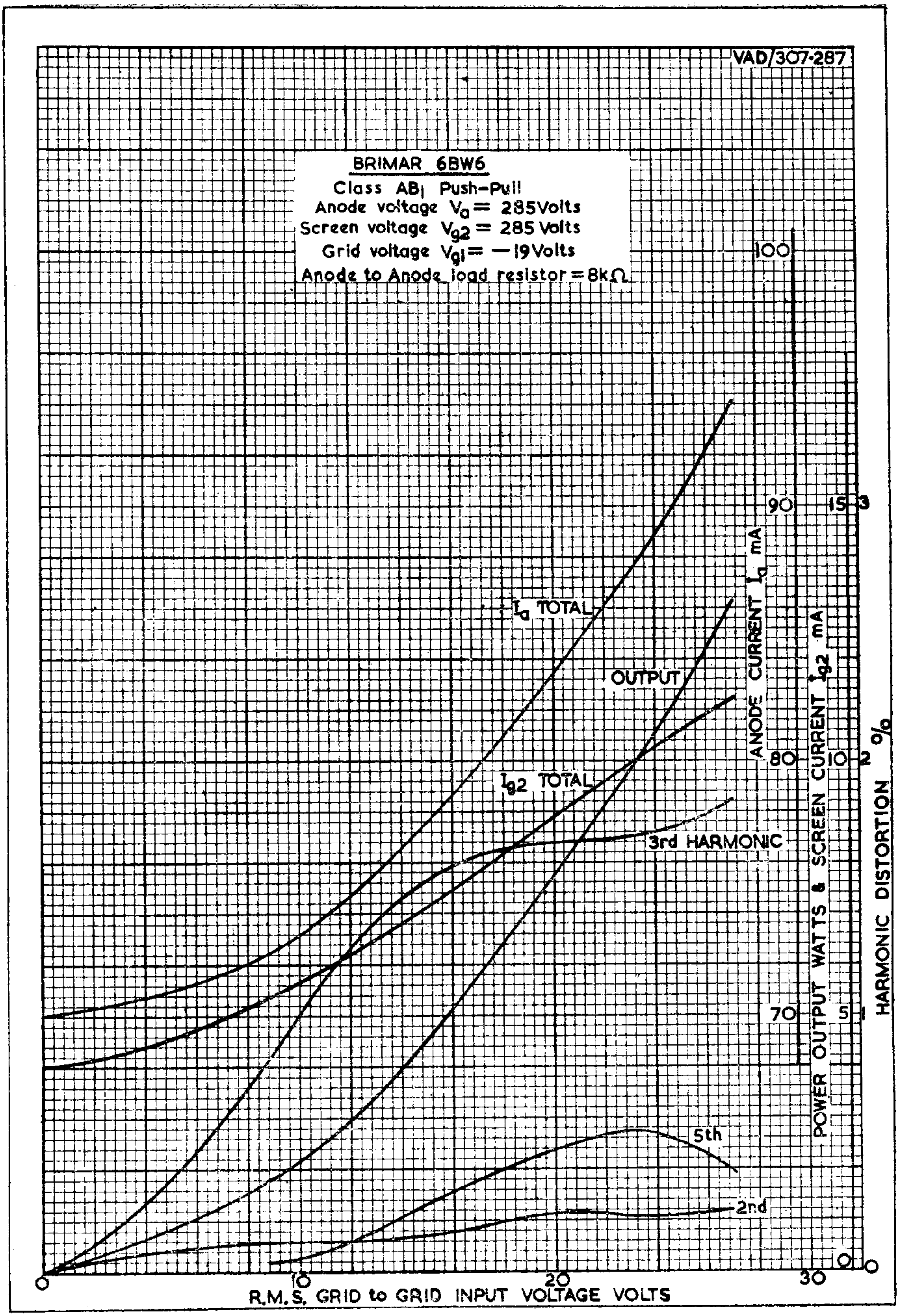

BRIMAR 6BW6
Class 'A' Push-Pull
Anode voltage V_a = 250Volts
Screen voltage V_{g2} = 250Volts
Grid voltage V_{g1} = −12·5Volts
Total anode current I_a = 90−96mA
Anode to Anode load resistor = 10kΩ
I_{g2} TOTAL
OUTPUT
3rd HARMONIC
2nd
HARMONIC DISTORTION %
POWER OUTPUT WATTS & SCREEN CURRENT I_{g2} mA
R.M.S. GRID to GRID INPUT VOLTAGE VOLTS
0
2·5
5
7·5
0
5
10
15
0
5
10
15
20
VAD/307·283


BRIMAR 6BW6
Class 'A' Push-Pull
Anode voltage V_a = 315Volts
Screen voltage V_{g2} = 250Volts
Total anode current I_a = 98mA
Anode to Anode load resistor = 10kΩ
Cathode bias resistor R_k = 125Ω
I_{g2}
TOTAL
OUTPUT
3rd HARMONIC
5th
2nd
VAD/307·284
HARMONIC DISTORTION %
POWER OUTPUT WATTS & SCREEN CURRENT I_{g2} mA
R.M.S. GRID to GRID INPUT VOLTAGE VOLTS
7·5
5
2·5
0
15
10
5
0
5
10
15
20

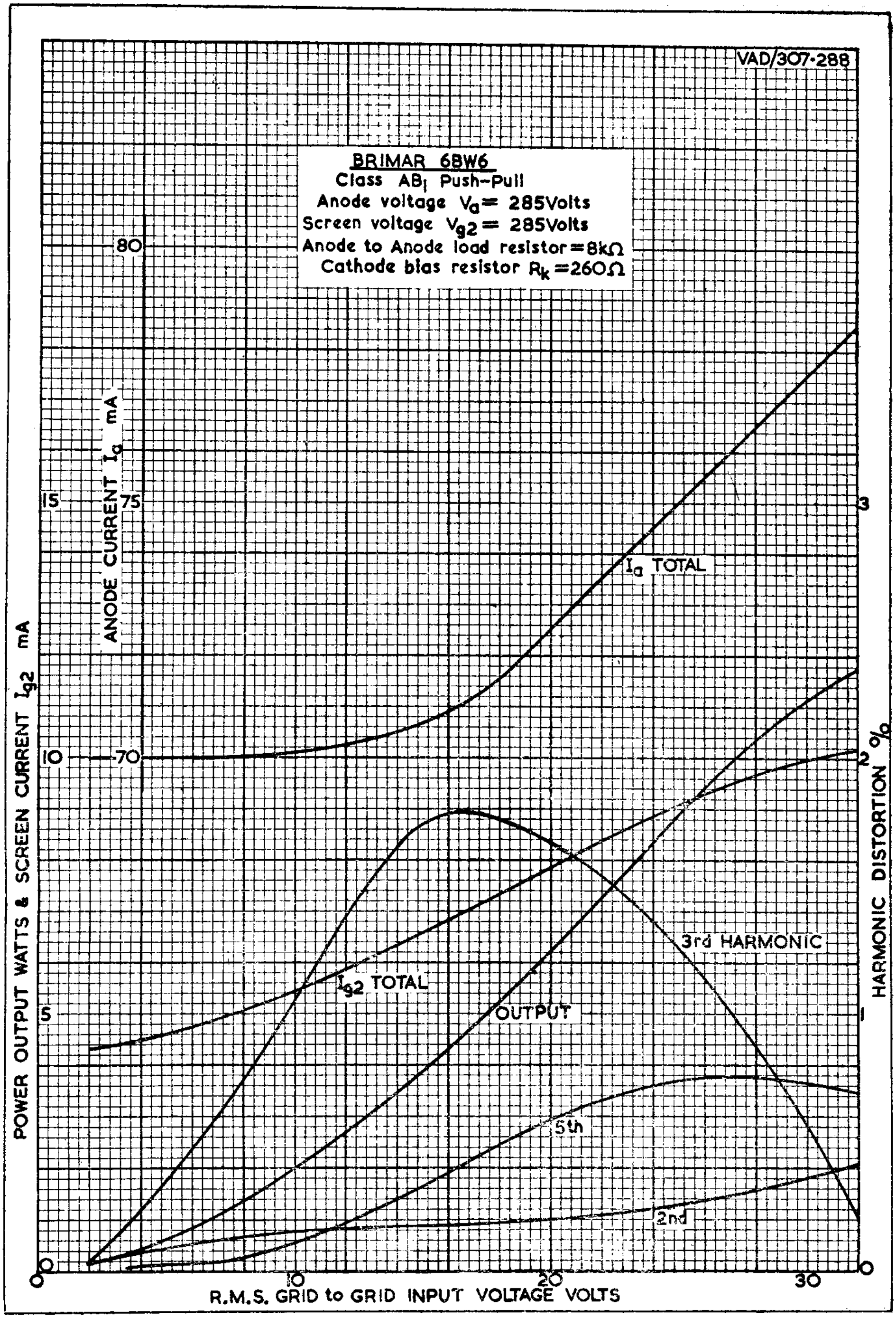


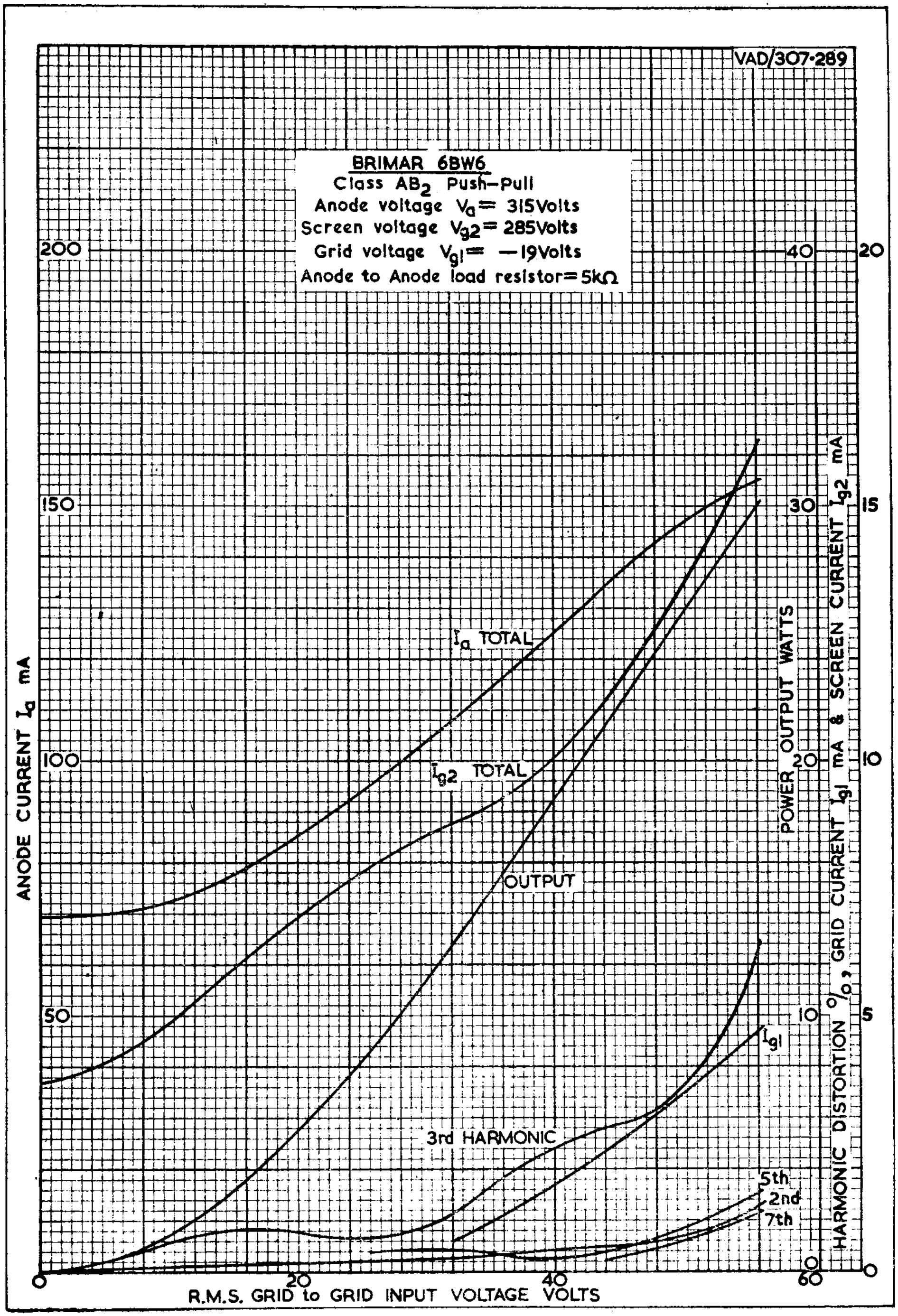
BRIMAR 6BW6
Class AB_1 Push–Pull
Anode voltage V_a = 250Volts
Screen voltage V_{g2} = 250Volts
Grid voltage V_{g1} = −15Volts
Anode to Anode load resistor = 10kΩ
HARMONIC DISTORTION %
POWER OUTPUT WATTS & SCREEN CURRENT I_{g2} mA
ANODE CURRENT I_a mA
I_a TOTAL
I_{g2} TOTAL
OUTPUT
3rd HARMONIC
2nd
R.M.S. GRID to GRID INPUT VOLTAGE VOLTS
VAD/307-285

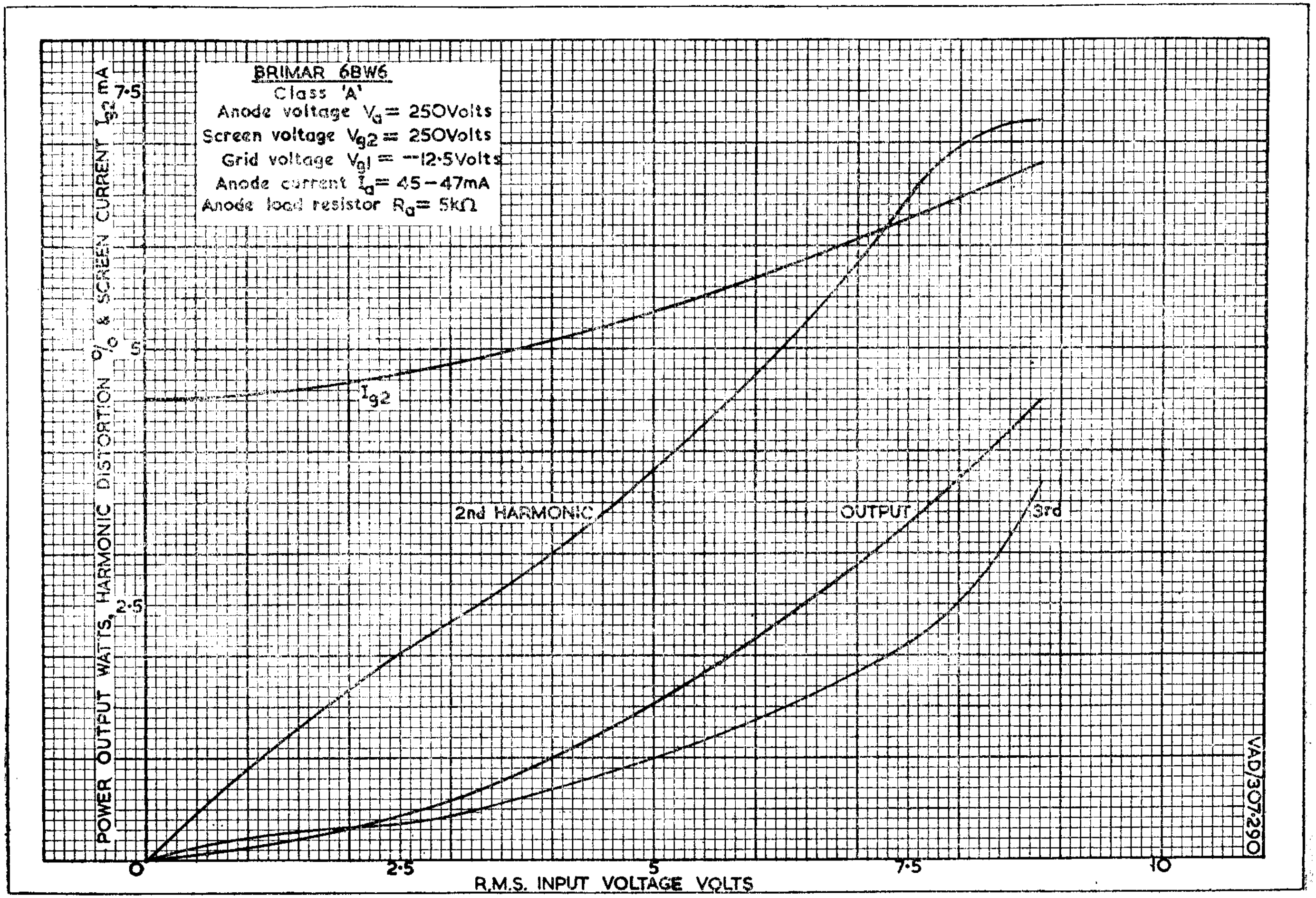

VAD/307-286
BRIMAR 6BW6
Class AB1 Push-Pull
Anode voltage Va = 250Volts
Screen voltage Vg2 = 250Volts
Anode to Anode load resistor = 10kΩ
Cathode bias resistor Rk = 200Ω
Ia TOTAL
Ig2 TOTAL
OUTPUT
3rd HARMONIC
5th
2nd
ANODE CURRENT Ia mA
POWER OUTPUT WATTS & SCREEN CURRENT Ig2 mA
HARMONIC DISTORTION %
74
72
70
15
10
5
0
7·5
5
2·5
0
0
10
20
30
R.M.S. GRID to GRID INPUT VOLTAGE VOLTS

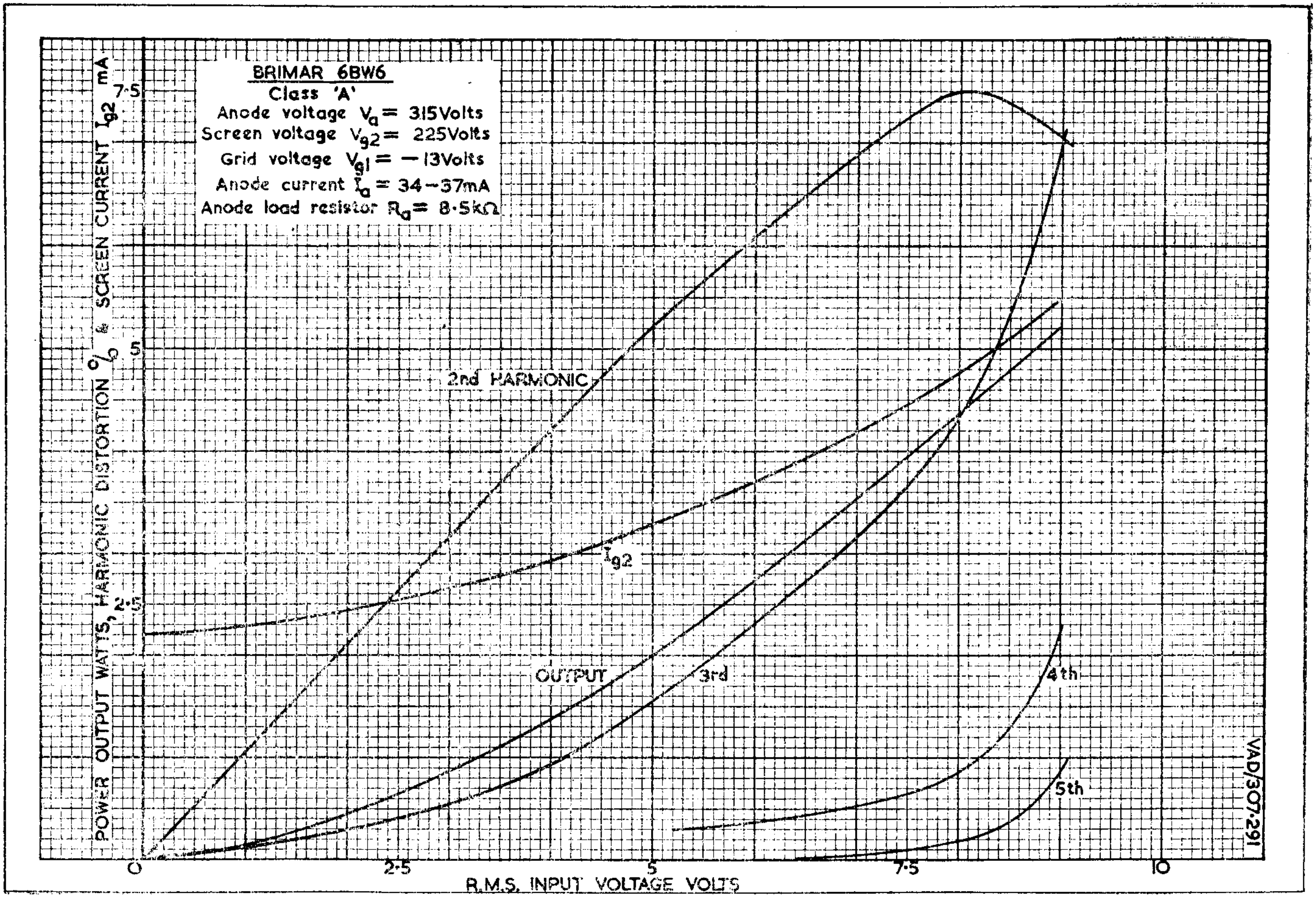


VAD/307-287
BRIMAR 6BW6
Class AB1 Push-Pull
Anode voltage Va = 285Volts
Screen voltage Vg2 = 285 Volts
Grid voltage Vg1 = −19 Volts
Anode to Anode load resistor = 8kΩ
Ia TOTAL
OUTPUT
Ig2 TOTAL
3rd HARMONIC
5th
2nd
100
90
80
70
15
10
5
3
2
1
0
10
20
30
ANODE CURRENT Ia mA
POWER OUTPUT WATTS & SCREEN CURRENT Ig2 mA
HARMONIC DISTORTION %
R.M.S. GRID to GRID INPUT VOLTAGE VOLTS


VAD/307·288
BRIMAR 6BW6
Class AB1 Push-Pull
Anode voltage Va = 285Volts
Screen voltage Vg2 = 285Volts
Anode to Anode load resistor = 8kΩ
Cathode bias resistor Rk = 260Ω
ANODE CURRENT Ia mA
POWER OUTPUT WATTS & SCREEN CURRENT Ig2 mA
HARMONIC DISTORTION %
Ia TOTAL
Ig2 TOTAL
OUTPUT
3rd HARMONIC
5th
2nd
R.M.S. GRID to GRID INPUT VOLTAGE VOLTS


VAD/307-289
BRIMAR 6BW6
Class AB_2 Push-Pull
Anode voltage V_a = 315 Volts
Screen voltage V_{g2} = 285 Volts
Grid voltage V_{g1} = −19 Volts
Anode to Anode load resistor = 5kΩ
I_a TOTAL
I_{g2} TOTAL
OUTPUT
3rd HARMONIC
I_{g1}
5th
2nd
7th
ANODE CURRENT I_a mA
POWER OUTPUT WATTS
HARMONIC DISTORTION %, GRID CURRENT I_{g1} mA & SCREEN CURRENT I_{g2} mA
R.M.S. GRID to GRID INPUT VOLTAGE VOLTS
0
20
40
60
50
100
150
200
10
30
5
15


BRIMAR 6BW6
Class 'A'
Anode voltage Va = 250Volts
Screen voltage Vg2 = 250Volts
Grid voltage Vg1 = −12·5Volts
Anode current Ia = 45−47mA
Anode load resistor Ra = 5kΩ
Ig2
2nd HARMONIC
OUTPUT
3rd
POWER OUTPUT WATTS, HARMONIC DISTORTION % & SCREEN CURRENT Ig2 mA
7·5
5
2·5
0
2·5
5
7·5
10
R.M.S. INPUT VOLTAGE VOLTS
VAD/307·290



BRIMAR 6BW6
Class 'A'
Anode voltage V_a = 315Volts
Screen voltage V_{g2} = 225Volts
Grid voltage V_{g1} = −13Volts
Anode current I_a = 34−37mA
Anode load resistor R_a = 8·5kΩ
2nd HARMONIC
I_{g2}
OUTPUT
3rd
4th
5th
POWER OUTPUT WATTS, HARMONIC DISTORTION % & SCREEN CURRENT I_{g2} mA
R.M.S. INPUT VOLTAGE VOLTS
0
2·5
5
7·5
10
VAD/307·291

BRIMAR

RECEIVING VALVE

6CD6G

APPLICATION REPORT VAD/507.9

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

Issued May, 1952.

1.0 INTRODUCTION: The Brimar 6CD6G is a high slope tetrode designed for operation as the line scan output valve in television receivers employing wide angle deflection cathode ray tubes. A particular feature is its high peak anode current capacity with low anode and screen voltage making it suitable for use from a low voltage HT rail. It is intended for use in conjunction with an efficiency diode so that the HT voltage is supplied partly by the receiver power supply and partly by the energy stored in the magnetic circuit. Used in this way the 6CD6G is capable of supplying the power necessary for the scan and E.H.T. voltage of wide angle CR tubes up to 17 in. diagonal at least.

2.0 DESCRIPTION: The valve consists of a low impedance tetrode utilising a twin cathode assembly to obtain high cathode emission. Special precautions have been taken to ensure adequate screen grid cooling to prevent screen primary emission. The top and bottom support micas are sprayed and slotted so that a long leakage path exists from the other electrodes to the anode, which is brought out to a top cap. This is necessary as the valve must withstand several thousand volts peak on its anode during the fly-back pulse.

The whole structure is mounted in an ST16 bulb and based with an International Octal Base.

3.0 CHARACTERISTICS:

3.1 Cathode:	Indirectly heated	
	Voltage	6·3 volts
	Current (Nominal)	2·5 amperes
	Max. Heater to Cathode Voltage	250 volts
3.2 Dimensions:	Max. Overall Length	5-11/16 ins.
	Max. Diameter	2-1/16 ins.
	Max. Seated Height	5-1/8 ins.
3.3 Base:	International Octal, Medium Shell, 6 Pin	
3.4 Basing Connections:	Pin 1 No Connection NC	
	Pin 2 Heater h	
	Pin 3 Cathode, Beam Plates k, bp	
	Pin 4 No Pin NP	
	Pin 5 Control Grid g_1	
	Pin 6 No Pin NP	
	Pin 7 Heater h	
	Pin 8 Screen Grid g_2	
	T.C. Anode a	

3.5 Mounting Position: The valve may be mounted vertically with the base up or down, but in the former case the bulb should be supported in some way. Horizontal mounting may be used if the vertical plane passes through both Pins 2 and 7.

3.6 Inter-electrode Capacitances:

NO EXTERNAL SHIELD:

Input	26 pF
Output	10 pF
Anode to Grid	1·0 pF
Heater to Cathode	20 pF

3.7 Ratings:

TETRODE CONNECTED:

Max. DC Anode Voltage	700 volts
Max. Peak Positive Anode Voltage*	6,000 volts
Max. Peak Negative Anode Voltage*	—1,500 volts

3.7 RATINGS—*continued*

Max. Anode Dissipation	15 watts
Max. DC Screen Voltage	175 volts
Max. Screen Dissipation	3·0 watts
Max. DC Anode Current	170 mA
Max. Peak Cathode Current	500 mA
Max. DC Grid Voltage	—50 volts
Max. Peak Grid Voltage*	—150 volts
Max. Grid 1 Circuit Resistance	1·0 MΩ
Max. Bulb Temperature (at hottest point)	210° C

* For normal television service where the pulse width does not exceed 15% of the duty cycle. For the present B.B.C. 405 lines 25 frame interlaced system this is approximately 15 μ seconds.

TRIODE CONNECTED (g_2 connected to anode):

Max. DC Anode Voltage	200 volts
Max. Anode Dissipation	16·5 watts
Max. DC Anode Current	180 mA
Max. DC Grid 1 Voltage	—50 volts
Max. Grid 1 Circuit Resistance	1 MΩ
Max. Bulb Temperature (at hottest point)	210° C

3.8 Static Characteristics:

TETRODE CONNECTION:

Anode Voltage	175	200	volts
Screen Voltage	175	150	volts
Grid Voltage	—30	—30	volts
Anode Current	100	64	mA
Screen Current	6	3	mA
Mutual Conductance	7·5	6·7	mA/V
Anode Impedance	10,000	15,000	ohms
Inner Amplification Factor ($\mu_{g1\ g2}$)	3·8	3·5	

TRIODE CONNECTION (g_2 connected to a):

Anode Voltage	200	volts
Grid Voltage	—42	volts
Anode Current	75	mA
Mutual Conductance	6·2	mA/V
Anode Impedance	570	ohms

3.9 Characteristic Curves: Curves are attached to this report as follows:

Anode and Screen Currents versus Anode Voltage V_{g2} 175 volts	307·323
Anode and Screen Currents versus Anode Voltage V_{g2} 150 volts	307·269
Anode and Screen Currents versus Anode Voltage V_{g2} 125 volts	307·322
Anode and Screen Currents versus Anode Voltage V_{g2} 100 volts	307·321
Anode Current versus Anode Voltage, Triode Connected	307·324

4.0 TYPICAL OPERATION:

4.1 Television Line Output Valve: A circuit is shown on 307·52 giving a basic arrangement for a television line output stage using the 6CD6G in conjunction with the 6U4GT efficiency diode. The energy stored in the magnetic field of the line output transformer and deflector coils is released in the oscillations appearing during the fly-back period. The efficiency diode permits only the normal overswing to take place and damps out the oscillations. The current in the overswing is forced to decay in a linear manner through the deflector coils by the linearising coil and condensers, and provides nearly half the scan power. The remainder of the scanning current is supplied directly by the 6CD6G. The DC voltage available from the efficiency diode is connected in series with the anode supply to the 6CD6G from the HT rail of the receiver. 150 to 250 volts of boost are available from this source making operation from an HT rail as low as 180 volts quite possible. The power supply, therefore, has to supply the losses in the circuit, the recovered energy being available for recirculation at the beginning of each scanning cycle.

To obtain the highest possible efficiency it is important that the iron and copper losses in the output transformer and deflector coils should be as low as possible. This requires that a low loss core material must be employed and that it should have a high permeability to reduce, as far as possible, the number of turns necessary for the required inductance.

4.11 Grid Drive Requirements: The 6CD6G must be cut off rapidly and maintained at cut-off during the fly-back period. The rapidity of cut-off is important as on it depends the maximum E.H.T. voltage that may be derived from the positive fly-back pulse. The 6CD6G must be maintained at cut-off during the fly-back period as if it is then conducting it absorbs the energy normally recoverable from the magnetic circuit. To accomplish this rapid cut-off the grid drive waveshape of the 6CD6G should have a sharp negative peak, which is normally obtained by shunting a resistance capacity peaking network across the grid to earth circuit.

Care must be taken that the maximum grid to cathode voltage of —150 volts is not exceeded. Normally a peak to peak drive voltage of 130 volts is adequate. The valve should be worked in a Class 'B' condition, the point of commencement of conduction coinciding with the point where the scan power from the efficiency diode is exhausted, which occurs a little to the left of screen centre. If too much drive is applied overlapping of the scan occurs at the centre and bright vertical lines appear in this region of the picture.

4.12 Protection in the Event of Drive Failure: A small amount of cathode bias is desirable to protect the 6CD6G in the event of failure of the drive voltage, as the valve would then be without bias. As the screen grid is supplied through a series resistor the electrode voltages fall to a low value and protection is not difficult. The 6CD6G will withstand short period overloads of up to 30 watts anode dissipation without harm.

4.13 Screen Dissipation: The maximum screen dissipation should not be exceeded under operating conditions or screen primary emission is liable to appear. This is caused by overheating of the screen which then emits electrons to the anode during the time the latter is highly positive. This occurs during the flyback period when the valve should be cut-off, and the effect is the same as if true cut-off has not been achieved. The valve then absorbs some of the recovery energy and amplitude of scan and E.H.T. voltage suffers.

4.14 Peak Anode Voltage: On the peak of the flyback pulse the anode voltage rises to a value the amplitude of which depends upon the rapidity of cut-off, the peak value of the anode current the instant before cut-off, the inductance of that portion of the line output transformer in series with the anode and the total effective stray capacitance appearing across the anode to earth circuit. This last factor, the stray capacitance, is of great importance; a few extra picofarads can cause several per cent reduction in the E.H.T. voltage, particularly on the overwind section where the lead to the anode of the E.H.T. rectifier is attached.

The peak anode voltage must not be allowed to exceed 6,000 volts positive. If there is any doubt as to whether this figure is being reached a check should be carried out with a peak reading voltmeter. A convenient arrangement for this purpose consists of a 1T2 rectifier, its filament supplied from a small 1·5 volt cell, connected in series with an electrostatic voltmeter and small reservoir condenser. The rectifier and battery can be mounted on a probe to reduce self capacity and simplify insulation problems. The application of the meter to the circuit will involve a slight drop in peak voltage due to capacity and leakage loading; the extent of this drop, which can normally be neglected, can be estimated by observation of the change in picture brightness of the CR Tube.

4.15 Peak Cathode Current: The circuit should be so designed that the peak cathode current is not greater than 400 mA, as although the 6CD6G is capable of supplying a higher peak current than this, due allowance must be made for deterioration during valve life.

4.16 Practical Circuits: For complete circuits with component specifications and full operating conditions reference should be made to the circuit reports on 'Time Bases for Wide Angle CR Tubes'. In these reports will be found specifications for the line output transformer width and linearity controls. Further similar circuit reports will be issued as new components and cathode ray tubes become available.

4.2 Audio Frequencies: The 6CD6G may be used as an audio frequency power output valve either tetrode or triode connected. Although not designed with this application in view its low impedance and low operating screen voltage make it of use where the anode voltage supply is limited. Below is given a table summarizing the characteristics under Class 'A' conditions.

4.21 TRIODE CONNECTED (g_2 connected to a):

Single Ended Class 'A' Amplifier:

Anode Voltage	200 volts
Grid Voltage	—32 volts
Cathode Bias Resistor	470 ohms
Anode Current (no signal)	72·5 mA
Peak Grid Input Voltage	28 volts
Anode Load	2,000 ohms
Power Output	1·5 watts
Total Harmonic Distortion	5%

The relation between power output, distortion and input signal is shown on 307·325.

Push-Pull Class 'A' Amplifier:

Anode Voltage	200 volts
Grid Voltage	—33·5 volts
Cathode Bias Resistor	240 ohms
Anode Current (no signal)	140 mA
Peak Grid to Grid Input Voltage	62 volts
Anode to Anode Load	1,500 ohms
Power Output	4·8 watts
Total Harmonic Distortion	2·7%

The relation between power output, distortion and input signal is shown on 307.326.

NOTE—A low value resistor of 50 to 100 ohms should be connected between grid 2 and anode when the valve is used triode connected to prevent parasitic oscillation.

4.22 TETRODE CONNECTED:

Single Ended Class 'A' Amplifier:

Anode Voltage	200 volts
Screen Voltage	110 volts
Grid Voltage	—14 volts
Cathode Bias Resistor	180 ohms
Anode Current (no signal)	80 mA
Screen Current (no signal)	2·4 mA
Screen Current (max. signal)	5·3 mA
Peak Grid Input Voltage	11·2 volts
Anode Load	1,500 ohms
Power Output	4·7 watts
Total Harmonic Distortion	13%

The relation between power output, distortion and input signal is shown on 307·327.

Push-Pull Class 'A' Amplifier:

Anode Voltage	110	200	volts
Screen Voltage	110	110	volts
Grid Voltage	—11·7	—14	volts
Cathode Bias Resistor	56	90	ohms
Anode Current (no signal)	200	160	mA
Screen Current (no signal)	13·2	4·8	mA
Screen Current (max. signal)	16·3	11·6	mA
Peak Grid to Grid Input Voltage	22·6	28	volts
Anode to Anode Load	1,000	3,000	ohms
Power Output	5·0	13·5	watts
Total Harmonic Distortion	1·0	1·75	%

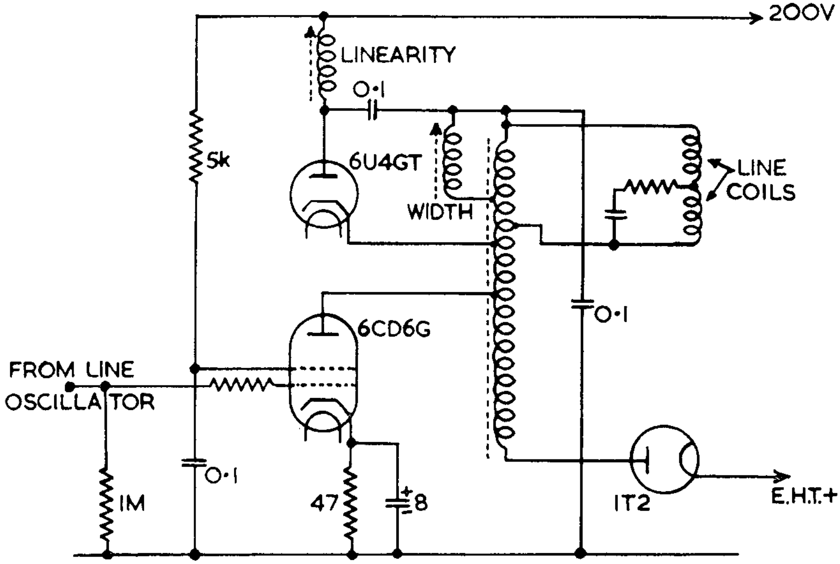
The relation between power output, distortion and input signal is shown on 307·328 for the 200 volt condition and 307·329 for the 110 volt condition.

Because its primary application is in television where Class 'A' working is not normal, greater emphasis is placed on operational testing in typical circuitry than on normal static tests under Class 'A' conditions. Consequently when the 6CD6G is used as an audio amplifier, rather wider variations in characteristics may be experienced than those which are normally encountered and it is partly for this reason that this valve is not recommended for audio frequency amplifier work.

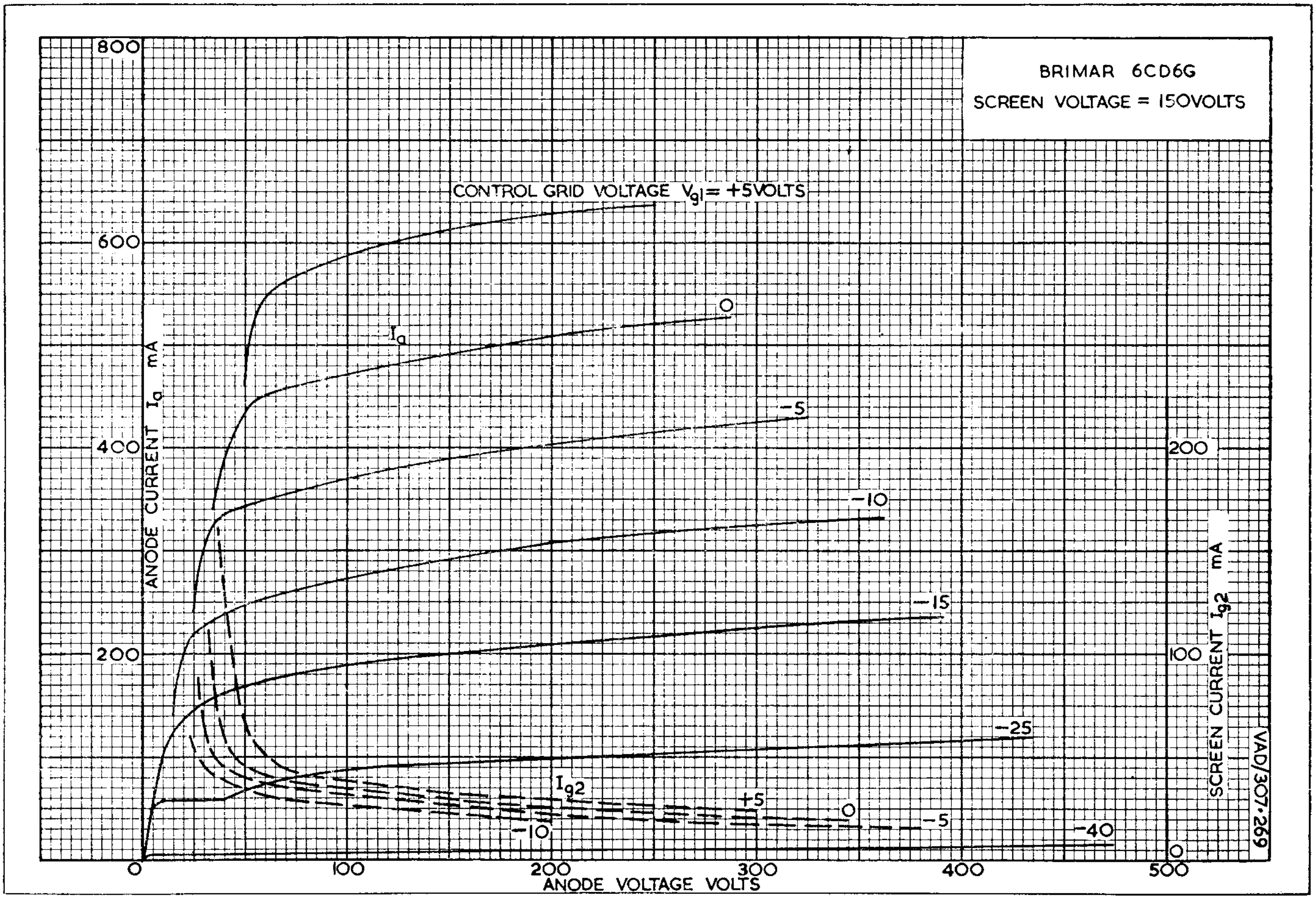
Nevertheless, there may be occasions when it is desired to take advantage of the special characteristics of this valve, so operating data and curves for AF amplifier service are included in this report.

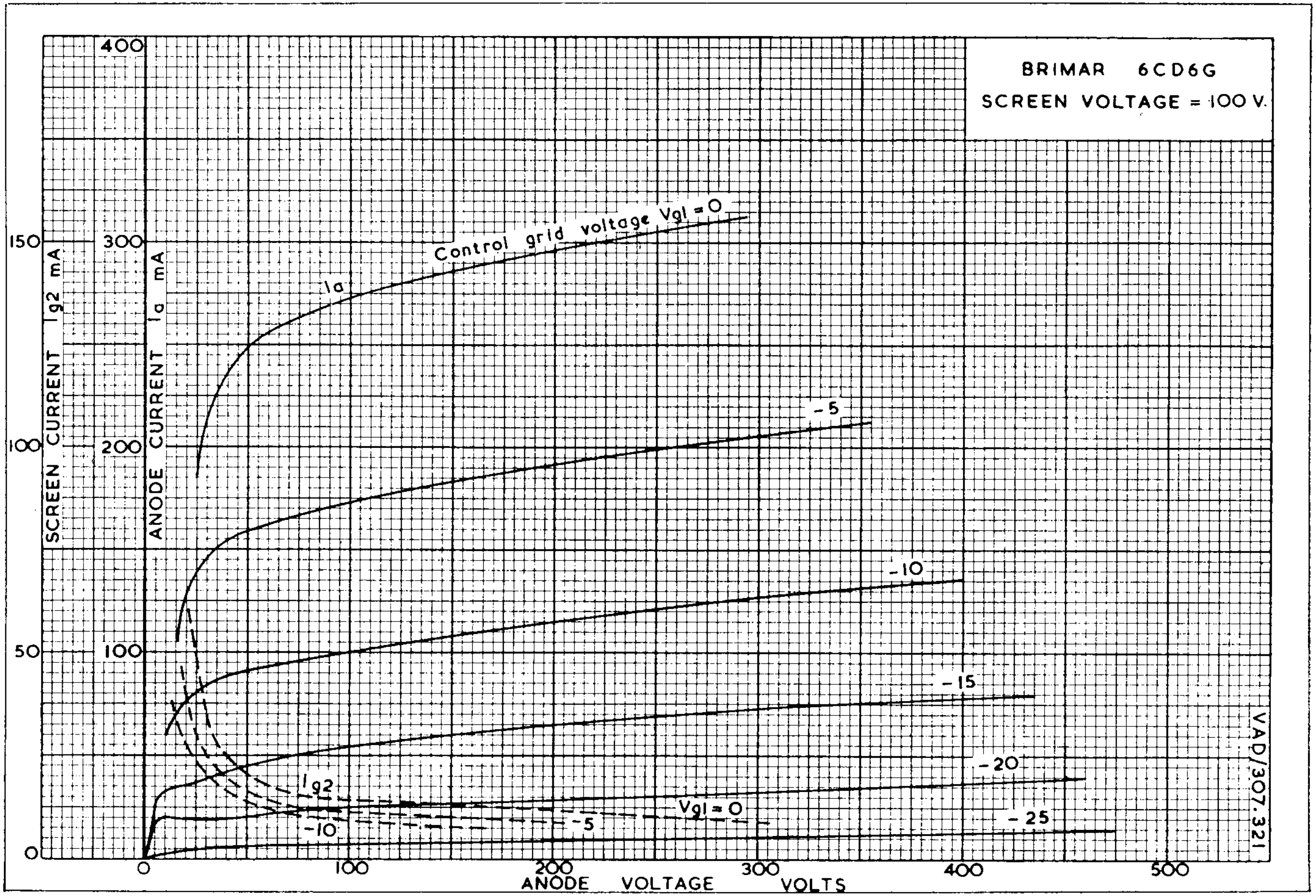
4.3 Series Stabiliser Valve in Regulated Power Supply: The 6CD6G is suitable for this application connected as a triode. Although the anode dissipation is rather low for this work (16·5 watts), the lower volt drop somewhat outweighs this disadvantage. Care must be taken that the anode dissipation is not allowed to exceed the rated figure when the power supply is delivering high current at low output voltage.

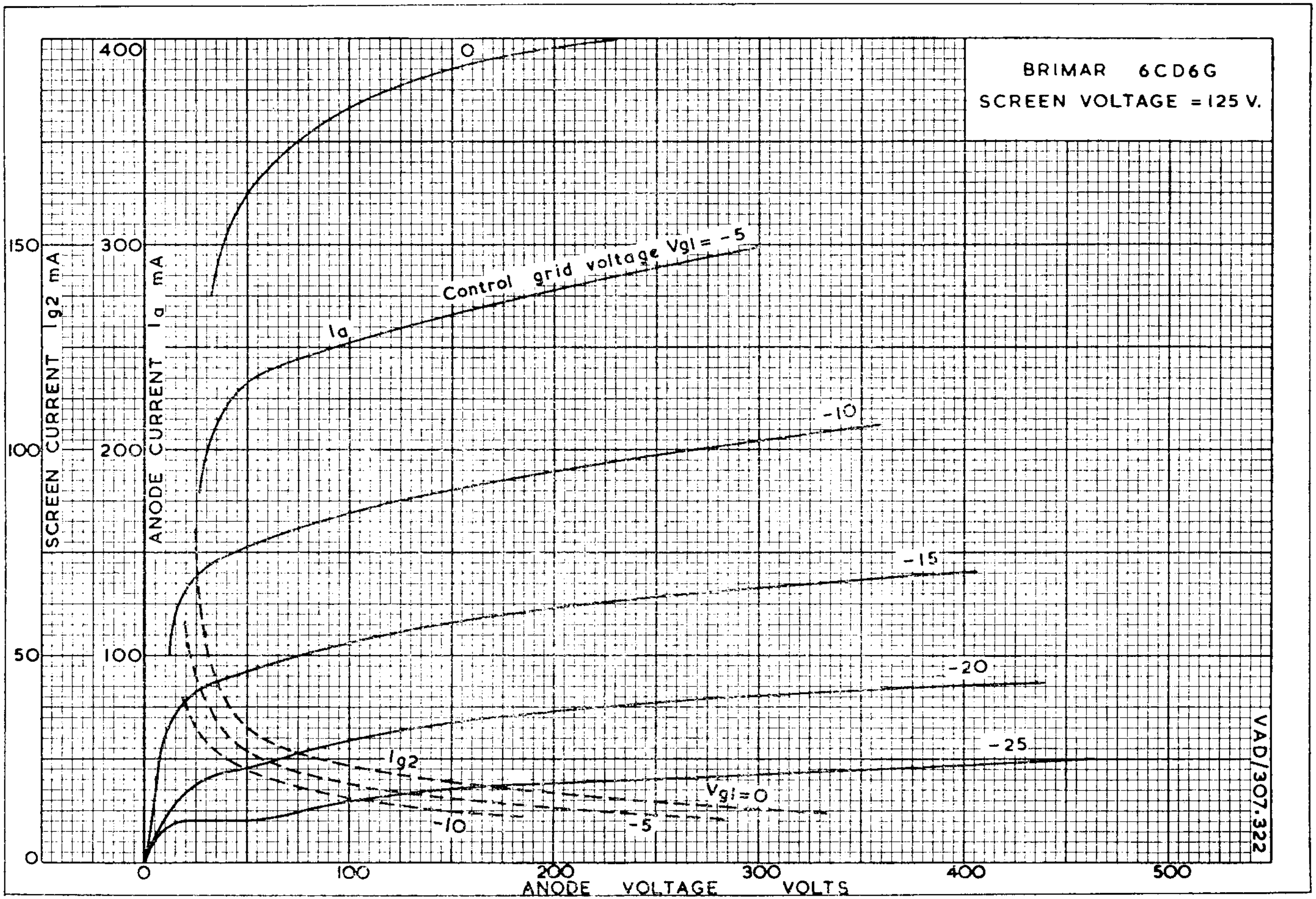
VAD/307.52

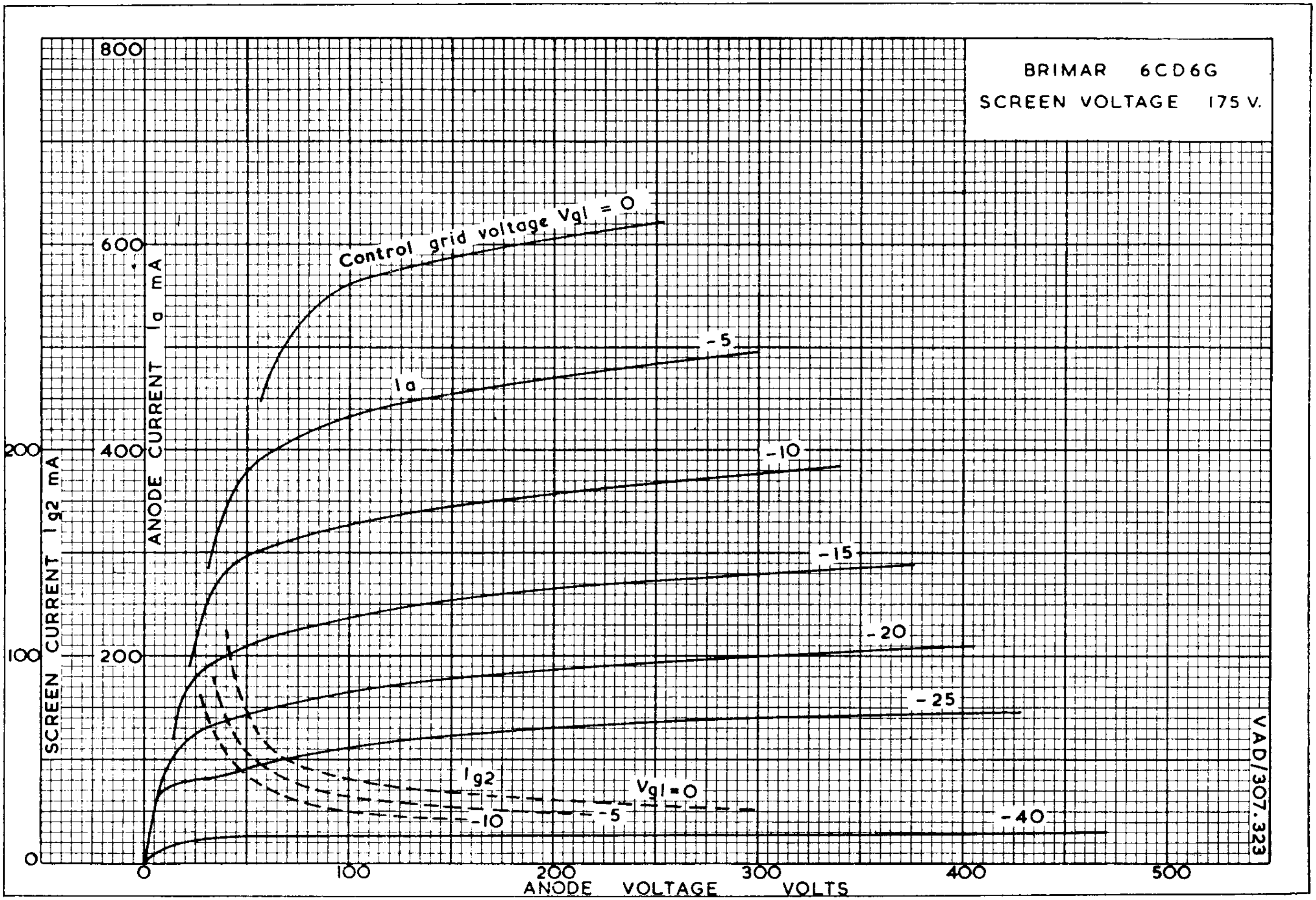


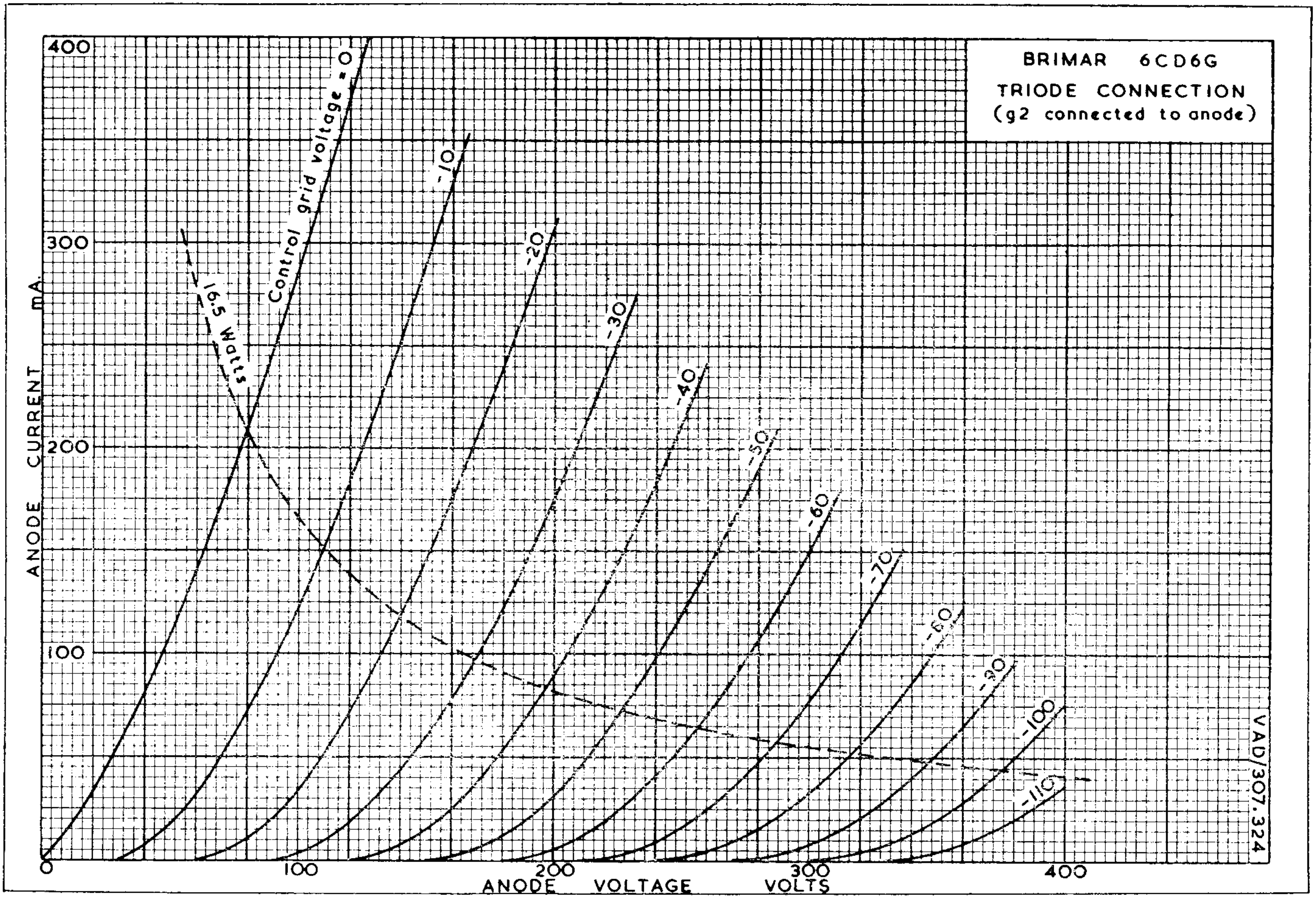
TELEVISION LINE OUTPUT CIRCUIT

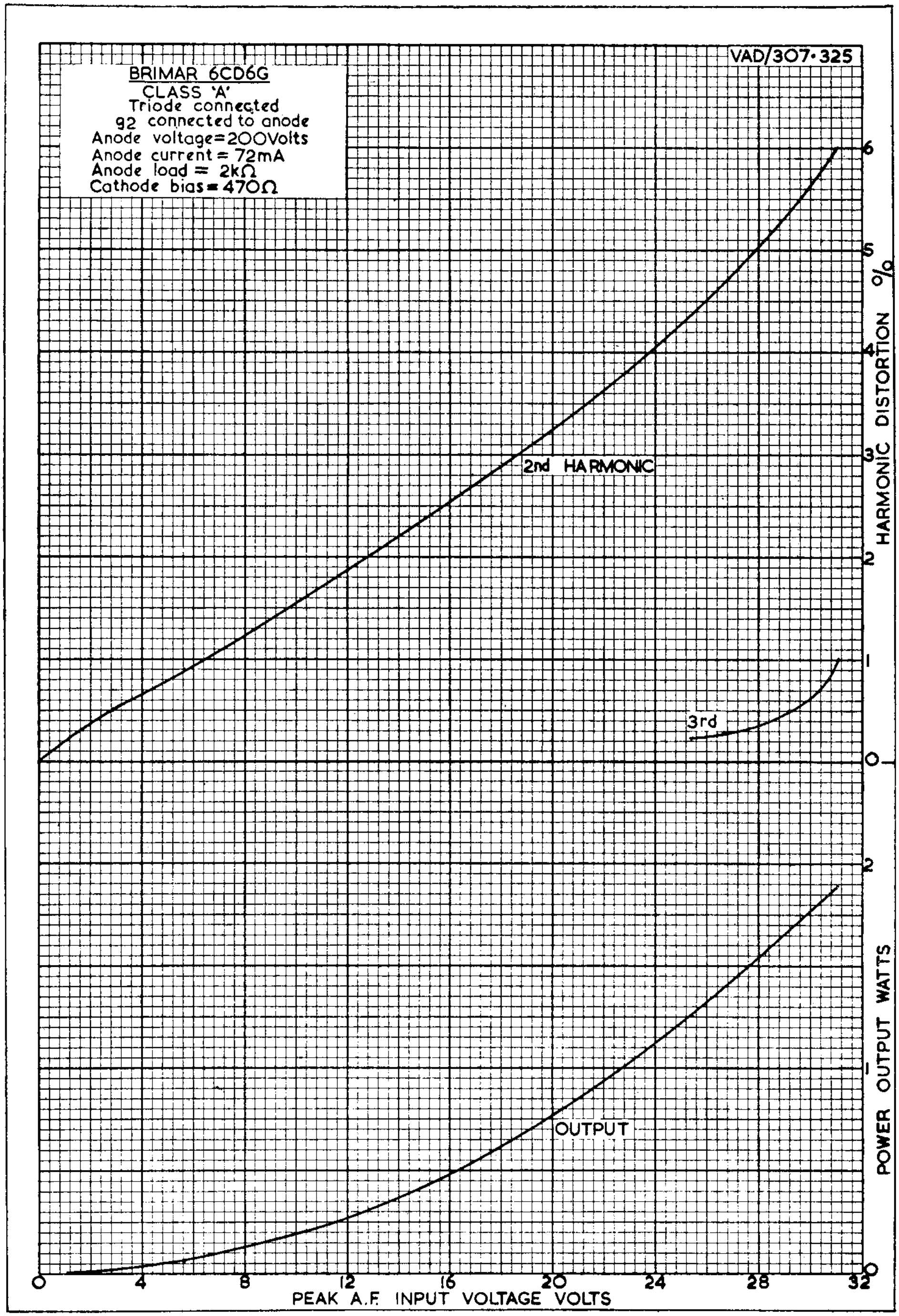

BRIMAR 6CD6G
SCREEN VOLTAGE = 150VOLTS
CONTROL GRID VOLTAGE V_{g1} = +5VOLTS
0
I_a
-5
-10
-15
-25
-40
I_{g2}
+5
0
-5
-10
0
ANODE CURRENT I_a mA
800
600
400
200
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
SCREEN CURRENT I_{g2} mA
200
100
0
VAD/307·269


BRIMAR 6CD6G
SCREEN VOLTAGE = 100 V.
Control grid voltage Vg1 = 0
Ia
-5
-10
-15
-20
-25
Ig2
Vg1 = 0
-5
-10
SCREEN CURRENT Ig2 mA
ANODE CURRENT Ia mA
ANODE VOLTAGE VOLTS
VAD/307.321
0
50
100
150
100
200
300
400
0
100
200
300
400
500

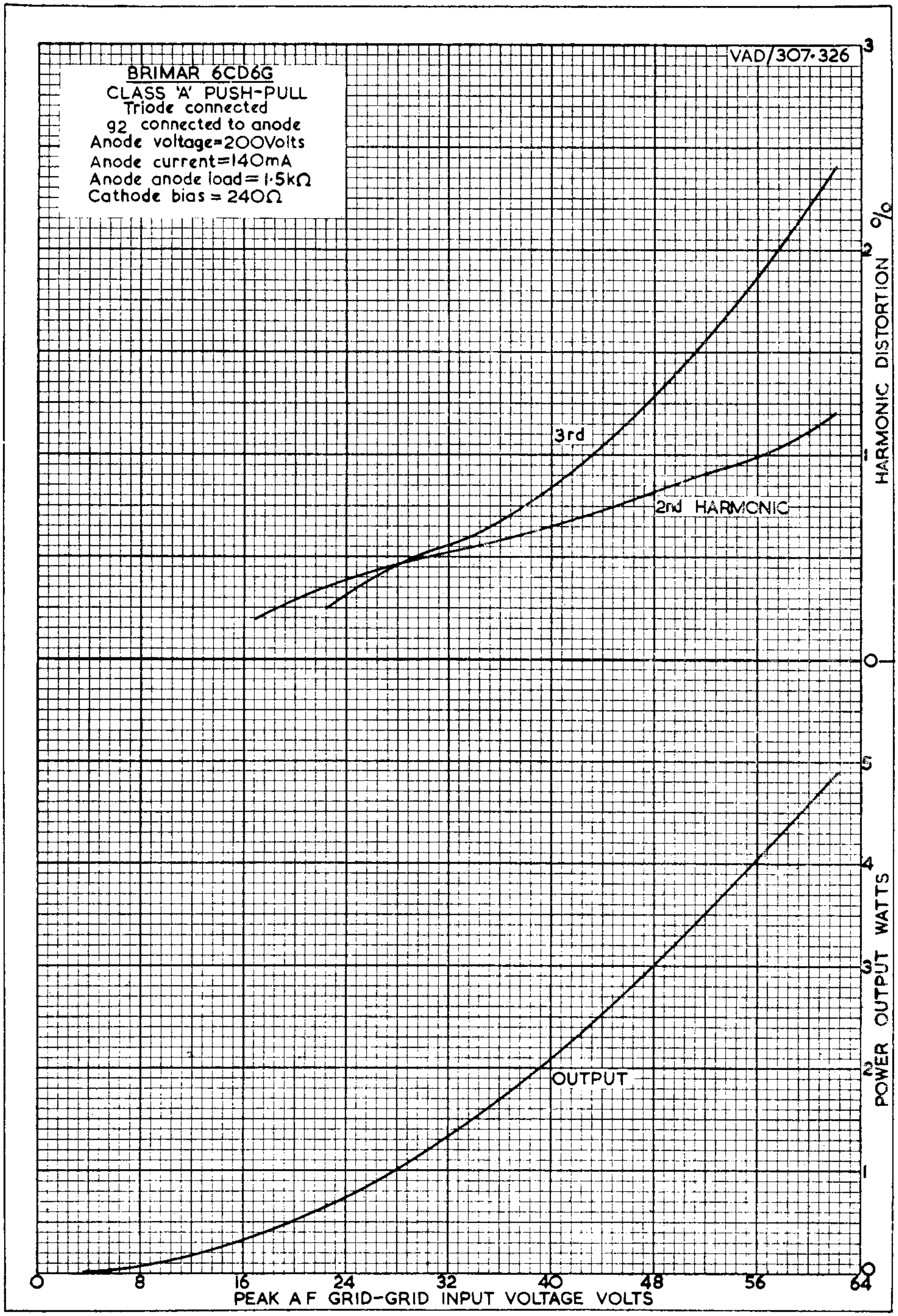

BRIMAR 6CD6G
SCREEN VOLTAGE = 125 V.
Control grid voltage Vg1 = -5
0
-10
-15
-20
-25
Ia
Ig2
Vg1 = 0
-5
-10
SCREEN CURRENT Ig2 mA
ANODE CURRENT Ia mA
ANODE VOLTAGE VOLTS
VAD/307.322
0
50
100
150
100
200
300
400
0
100
200
300
400
500


BRIMAR 6CD6G
SCREEN VOLTAGE 175 V.
Control grid voltage Vg1 = 0
-5
Ia
-10
-15
-20
-25
-40
Ig2
Vg1 = 0
-5
-10
ANODE CURRENT Ia mA
SCREEN CURRENT Ig2 mA
ANODE VOLTAGE VOLTS
0
100
200
300
400
500
200
400
600
800
VAD/307.323

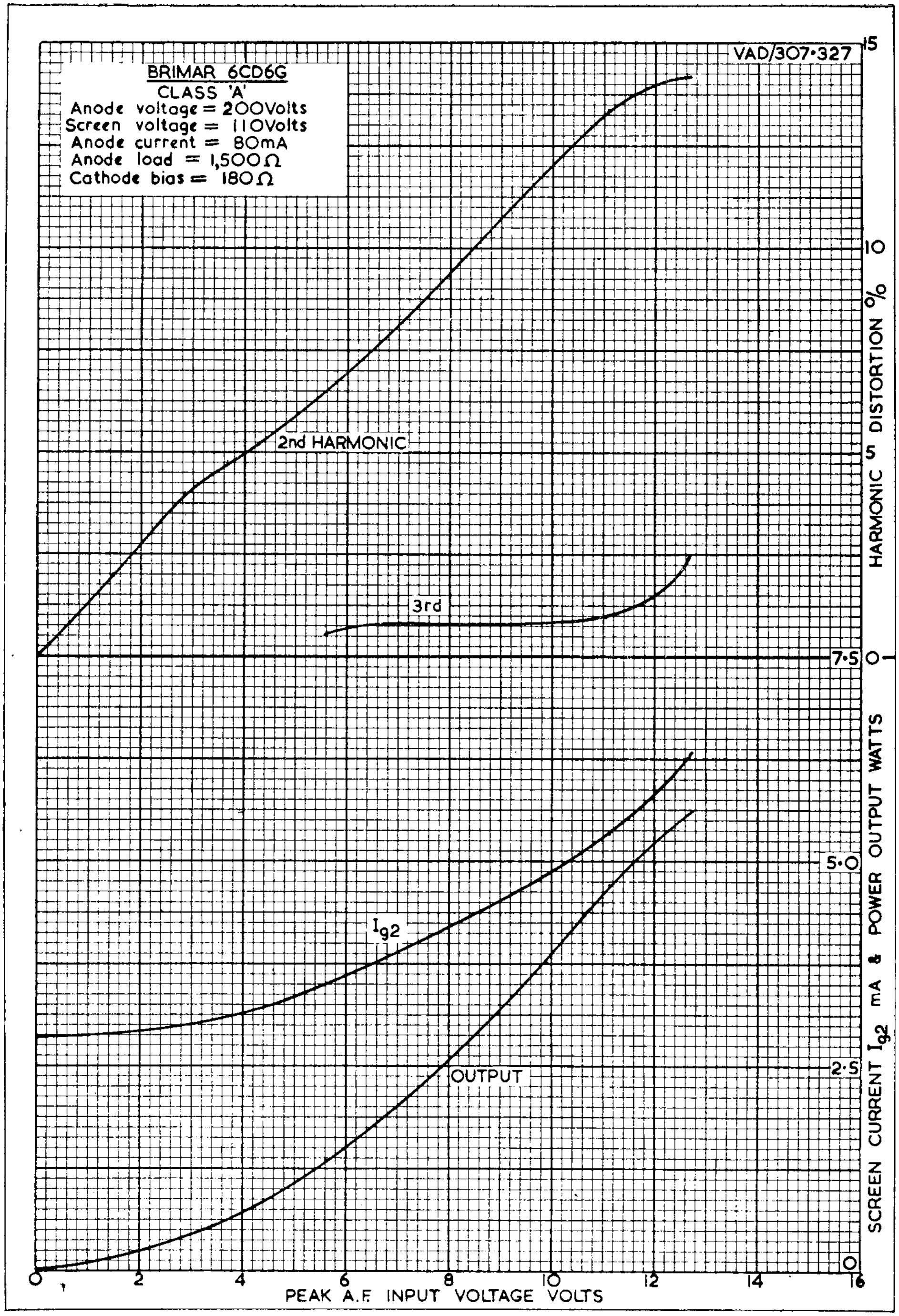

BRIMAR 6CD6G
TRIODE CONNECTION
(g2 connected to anode)
VAD/307.324
ANODE CURRENT mA.
ANODE VOLTAGE VOLTS
400
300
200
100
0
100
200
300
400
Control grid voltage = 0
16.5 Watts
-10
-20
-30
-40
-50
-60
-70
-60
-30
-100
-110



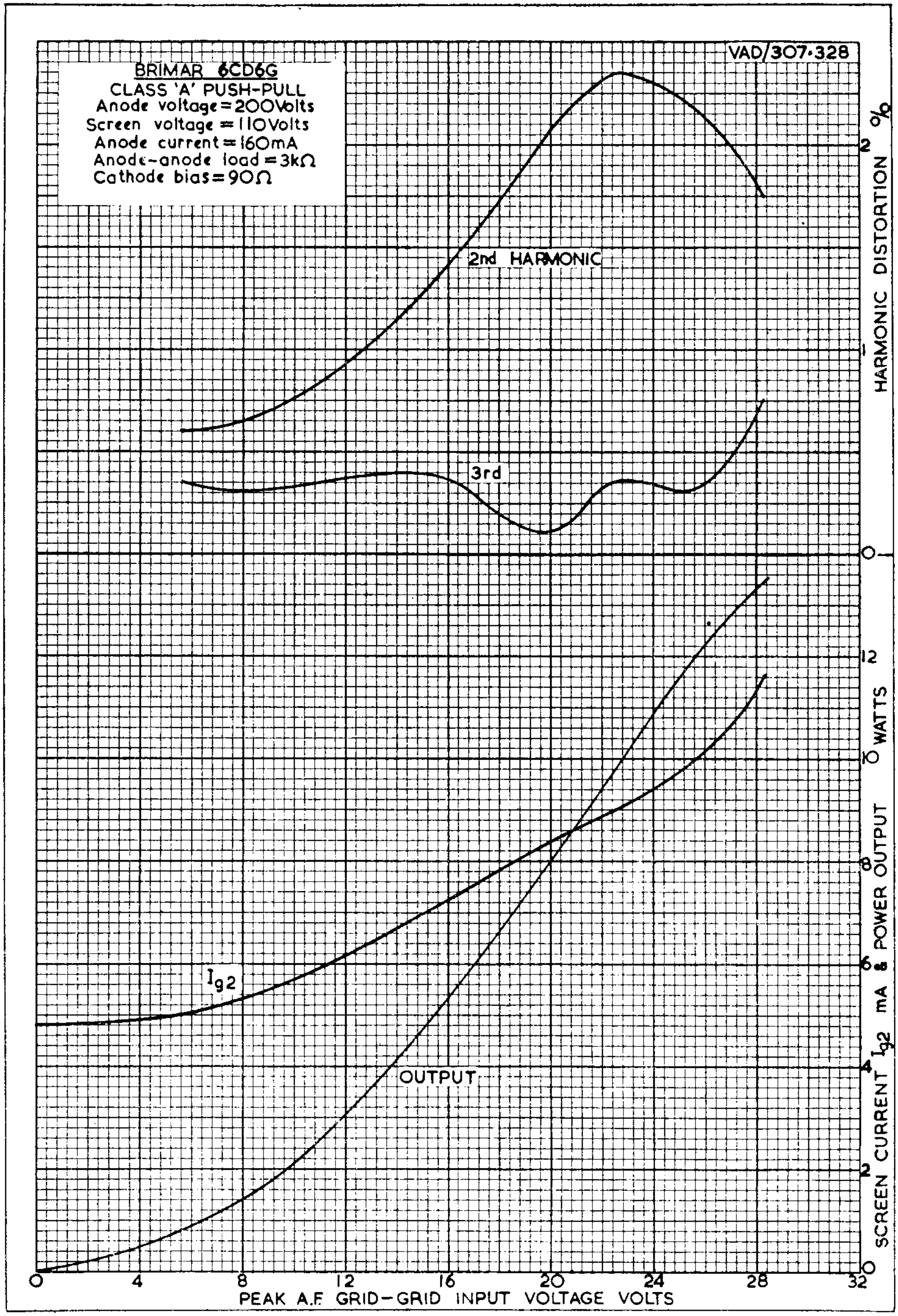
VAD/307·325
BRIMAR 6CD6G
CLASS 'A'
Triode connected
g2 connected to anode
Anode voltage=200Volts
Anode current=72mA
Anode load = 2kΩ
Cathode bias=470Ω
2nd HARMONIC
3rd
OUTPUT
HARMONIC DISTORTION %
POWER OUTPUT WATTS
PEAK A.F. INPUT VOLTAGE VOLTS
0
4
8
12
16
20
24
28
32
1
2
3
4
5
6



BRIMAR 6CD6G
CLASS 'A' PUSH-PULL
Triode connected
g2 connected to anode
Anode voltage=200Volts
Anode current=140mA
Anode anode load=1·5kΩ
Cathode bias=240Ω
VAD/307·326
3rd
2nd HARMONIC
OUTPUT
HARMONIC DISTORTION %
POWER OUTPUT WATTS
PEAK A F GRID-GRID INPUT VOLTAGE VOLTS
0
8
16
24
32
40
48
56
64
1
2
3
4
5



VAD/307·327
BRIMAR 6CD6G
CLASS 'A'
Anode voltage = 200Volts
Screen voltage = 110Volts
Anode current = 80mA
Anode load = 1,500Ω
Cathode bias = 180Ω
2nd HARMONIC
3rd
Ig2
OUTPUT
15
10
5
0
7·5
5·0
2·5
0
0
2
4
6
8
10
12
14
16
PEAK A.F. INPUT VOLTAGE VOLTS
HARMONIC DISTORTION %
SCREEN CURRENT Ig2 mA & POWER OUTPUT WATTS



VAD/307·328
BRIMAR 6CD6G
CLASS 'A' PUSH-PULL
Anode voltage = 200Volts
Screen voltage = 110Volts
Anode current = 160mA
Anode-anode load = 3kΩ
Cathode bias = 90Ω
2nd HARMONIC
3rd
I_{g2}
OUTPUT
HARMONIC DISTORTION %
SCREEN CURRENT I_{g2} mA & POWER OUTPUT WATTS
PEAK A.F GRID-GRID INPUT VOLTAGE VOLTS
0
4
8
12
16
20
24
28
32
1
2
0
2
4
6
8
10
12

VAD/307·329
BRIMAR 6CD6G
CLASS 'A' PUSH-PULL
Anode voltage = 110Volts
Screen voltage = 110Volts
Anode current = 200mA
Anode anode load = 1kΩ
Cathode bias = 56Ω
2nd HARMONIC
3rd
HARMONIC DISTORTION %
I g2
OUTPUT
SCREEN CURRENT I g2 mA
POWER OUTPUT WATTS
PEAK A.F. GRID-GRID INPUT VOLTAGE VOLTS
0
4
8
12
16
20
24
28
32
1
2
3
4
5
6

BRIMAR

RECEIVING VALVE
6CH6

APPLICATION REPORT VAD/507.9

Standard Telephones and Cables Limited
FOOTSCRAY, KENT, ENGLAND

Issued January, 1952.

1.0 INTRODUCTION: The Brimar 6CH6 is an indirectly heated high slope pentode intended for use as a video amplifier valve. In addition the valve is useful in AF power output stages where high sensitivity is required. Its high slope also makes it eminently suited for use as a triode connected cathode follower amplifier having a low output impedance.

Its heater is intended for use in parallel with those of other valves in AC operated equipment.

2.0 DESCRIPTION: The valve is of miniature construction mounted in a T6½ bulb and is fitted with a B9A (Noval) base. Although g_3 is brought out separately to a pin, no purpose is served by connecting it to other than the cathode, as its potential has little effect on the main election stream. This is because it is not a grid as such but consists of beam confining plates.

Included in this report are characteristic curves and details of the performance of the valve as a video amplifier and AF output stage.

3.0 CHARACTERISTICS:

3.1 Cathode:

Indirectly heated	
Voltage	6·3 volts
Current (Nominal)	0·75 ampere
Max. DC Heater-Cathode potential	90 volts

3.2 Dimensions:

Max. Overall Length	2-5/8 ins.
Max. Diameter	7/8 in.
Max. Seated Height	2-3/8 ins.

3.3 Base: Type B9A (Noval)

- Pin 1 Internal Connection IC
- Pin 2 Control Grid g_1
- Pin 3 Cathode k
- Pin 4 Heater h
- Pin 5 Heater h
- Pin 6 Internal Connection IC
- Pin 7 Anode a
- Pin 8 Screen Grid g_2
- Pin 9 Suppressor Grid g_3

3.4 Ratings (Design centre, unless otherwise stated):

PENTODE CONNECTED:

Max. Anode Voltage	275 volts
Max. Screen Voltage	275 volts
Max. Anode Dissipation	12 watts
Max. Screen Dissipation	2·5 watts
Max. DC Cathode Current (Absolute)	65 mA
Max. Peak Cathode Current (Absolute)	1·5 amperes*
Max. Control Grid Circuit Resistance	100,000 ohms†
Max. Bulb Temperature (Absolute)	250° C

TRIODE CONNECTED (g_2 connected to a, g_3 connected to k):

Max. Anode Voltage	275 volts
Max. Anode Dissipation	12·5 watts
Max. DC Cathode Current (Absolute)	65 mA
Max. Peak Cathode Current (Absolute)	1·5 amperes*
Max. Grid Circuit Resistance	100,000 ohms†
Max. Bulb Temperature (Absolute)	250° C

* The duration of current flow must not exceed 2μ seconds, and must not be greater than 5% of the duty cycle.

† This value may be increased to 220,000 ohms if cathode bias is employed.

N.B.—The control grid of this valve is not designed to withstand any appreciable dissipation, therefore no positive DC grid current should be allowed to flow. Precautions must be taken, if the valve is operated at high frequency, to ensure that the AC capacitative current to the control grid is not excessive, otherwise the grid temperature may rise to a level which permits grid emission. This valve is not, therefore, recommended for use as a Class B or C amplifier, or as a frequency multiplier.

3.5 Inter-electrode Capacitances (measured with no external shield):

PENTODE CONNECTED:

c_{in}	14 pF
c_{out}	5·0 pF
$c_{g1,a}$	0·25 pF max.
$c_{h,k}$	7·0 pF

TRIODE CONNECTED:

c_{in}	8·0 pF
c_{out}	6·0 pF
$c_{g,a}$	6·0 pF

3.6 Characteristic Curves: Curves are contained in this report as follows:

I_a/V_a with V_{g2} 275 volts	No. 307·300
I_a/V_a ,, ,, 250 volts	No. 307·301
I_a/V_a ,, ,, 225 volts	No. 307·302
I_a/V_a ,, ,, 200 volts	No. 307·303
I_a/V_a ,, ,, 175 volts	No. 307·304
I_a/V_a ,, ,, 150 volts	No. 307·305
I_a/V_a ,, ,, 100 volts	No. 307·306
g_m and r_a/V_{g1} with various values of V_{g2}	No. 307·307
I_a/V_a Triode Connected	No. 307·310
μ, g_m and I_a/V_g Triode Connected	No. 307·311

4.0 TYPICAL OPERATION:

4.1 PENTODE CONNECTED:

Heater Voltage	6·3	6·3	volts
Anode Voltage	250	250	volts
Screen Voltage	200	250	volts
Grid Voltage	—2·5	—4·5	volts
Cathode Bias Resistor	54	100	ohms
Anode Current	40	40	mA
Screen Current	6·5	6·0	mA
Anode Impedance	60,000	50,000	ohms
Mutual Conductance	13	11	mA/V
Inner Amplification Factor	26	26	

4.2 TRIODE CONNECTED:

Heater Voltage	6·3	6·3	6·3	volts
Anode Voltage	150	200	250	volts
Grid Voltage	—1·5	—2·5	—4·5	volts
Cathode Bias Resistor	45	57	100	ohms
Anode Current	33	44	46	mA
Anode Impedance	2100	1820	1870	ohms
Mutual Conductance	12·5	14·5	13	mA/V
Amplification Factor	26·2	26·4	25·8	

5.0 Operation as an AF Power Output Stage: Where an output valve of high sensitivity is required, such as in circuits containing little or no AF amplification, the 6CH6 is well suited, provided the requirements do not include particularly low harmonic distortion. Due to its high slope, the characteristics have only a limited linear portion over which to accept the grid voltage swing, so that, except at low output levels, the harmonic distortion will be in the order of 7 to 10%. When used in push-pull the even harmonics mostly cancel, and the total distortion level is much lower.

5.1 Pentode Connected:

Class 'A' Single Ended:

Anode Voltage	250 volts
Screen Voltage	250 volts
Cathode Bias Resistor	100 ohms
Anode Current	40 mA
Screen Current (no signal)	6·0 mA
Screen Current (max. signal)	8·5 mA
Anode Load Impedance	6000 ohms
Peak Grid Input Voltage	3·5 volts
Power Output	3·0 watts
Total Harmonic Distortion	8·5%

Curves showing the relationship between power output, distortion and input voltage for the above conditions are given in 307·308.

Class 'A' Push-Pull:

Anode Voltage	250 volts
Screen Voltage	250 volts
Anode Current	80 mA
Cathode Bias Resistor	50 ohms
Screen Current (no signal)	12 mA
Screen Current (max. signal)	17·5 mA
Anode to Anode Load Impedance	9000 ohms
Peak Grid to Grid Input Voltage	9·0 volts
Power Output	8·0 watts
Total Harmonic Distortion	7·5%

The above conditions are for two valves.

Curves showing the relationship between power output, distortion and input voltage for the above conditions are given on 307·309.

5.2 TRIODE CONNECTED:

Class 'A' Single Ended:

Anode Voltage	250 volts
Cathode Bias Resistor	100 ohms
Anode Current	46 mA
Anode Load Impedance	4000 ohms
Peak Grid Input Voltage	4·5 volts
Power Output	0·8 watt
Total Harmonic Distortion	4%

Class 'A' Push-Pull:

Anode Voltage	250 volts
Cathode Bias Resistor	50 ohms
Anode Current	92 mA
Anode to Anode Load Impedance	5000 ohms
Peak Grid to Grid Input Voltage	9·0 volts
Power Output	1·8 watts
Total Harmonic Distortion	1%

6.0 Video Amplifier: Due to its high slope and relatively low output capacity, together with a high standing anode current, the 6CH6 is well suited for wide band amplifier applications where the load resistor must be low to permit working into a high capacity. A low value of anode load resistor is desirable when the overall output capacity is high, as it simplifies the correction for loss of high frequency response.

The normal methods of high frequency compensation are by anode or cathode correction. Examples are given of both methods, and typical performance curves are included.

6.1 Anode Compensation: To minimise the effect of capacity in shunt with the output impedance an inductance may be inserted in series with the anode load (shunt compensation), in series with the coupling connection (series compensation), or a combination of the two (series-shunt compensation) may be used. The inductance forms a resonant circuit with the effective output capacity at a frequency above the upper limit of the amplifier response. The rising resonance characteristic is used to counteract the falling load impedance seen by the valve at the upper frequency limit. The load resistor must also be so chosen that the gain at low frequencies, where the reactive effect is small, will be the same as at the upper frequency limit, where the reactive effect predominates. For the purpose of circuit design the upper limit of amplifier response will be considered to be the frequency at which the gain begins to fall below that obtained at mid-band frequencies.

6.11 Shunt Compensation: The most widely used method of anode compensation is by shunt peaking, i.e. the peaking inductance is connected in series with the anode load resistor. For design purposes the load resistor is usually made equal to the capacitative impedance at the maximum frequency, and the inductive impedance 1·5 times the capacitative impedance at maximum frequency. This results in the resonant frequency of the combination being $\sqrt{2}$ times the maximum frequency. If the resonant frequency is made too low the amplifier will exhibit a sharp rise in gain followed by a rapid cut-off. If the resonant frequency is made too high the response will fall away slowly, starting at a frequency lower than the desired upper limit. This may be used to advantage when a number of stages are connected in cascade, as any tendency for each stage to exhibit a sharp peak will lead to ringing on transients.

Under these conditions the design formulæ may be simplified to:

$$R_a = \frac{1}{2\pi f \text{ max. } C}$$

$$L = 0{\cdot}5\, C\, R_a{}^2$$

Where R_a is the anode load resistor in ohms, L is the peaking inductance in henries, C is the total output circuit capacity in farads, and f max. the upper frequency for uniform amplification.

Included in this report are curves showing the peak output voltage as a function of frequency for a typical shunt connected circuit with three values of load resistor and shunt capacity. Curve No. 307·312 shows a load of 1 kΩ, No. 306·313 a load of 2·2 kΩ, and No. 307·314 a load of 3·3 kΩ. Values of C given on the curves include the output capacity of the valve and holder, for which an allowance of 10 pF has been made, but do not include the self capacity of the coil. The values of L, C and R_a differ slightly from those obtained by calculation, this being due to the use of standard preferred value components of normal tolerance, and the fact that the coil self capacity is neglected.

6.12 Series Compensation: In this method the peaking inductance is connected in series with the coupling between the stages, thus separating the output capacity of one stage from the input capacity of the other. As the output capacity is usually less than the input capacity the value of R_a may be higher than with shunt compensation for a given upper frequency limit, with a corresponding increase in gain.

If it is assumed that c_{in} is twice the value of c_{out} the design formulæ with the same reservations as before may be simplified to:

$$R_a = \frac{1{\cdot}5}{2\pi \text{ f max. C}}$$

$$L = 0{\cdot}67 \text{ C } R_a^2$$

$$\text{Where C} = c_{in} + c_{out}$$

6.13 Shunt Series Compensation: This method is a combination of the methods 6.11 and 6.12, and yields a still higher gain than series peaking. With the same reservations as in 6.11 the design formulæ may be simplified to:

$$R_a = \frac{1{\cdot}8}{2\pi \text{ f max. C}}$$

$$L1 = 0{\cdot}12\text{C } R_a^2$$

$$L2 = 0{\cdot}52\text{C } R_a^2$$

Where L1 and L2 are the shunt and series inductances respectively.

6.2 Cathode Compensation: The basic principle of this method of compensation is that an inadequately decoupled cathode resistor provides degeneration at low frequencies, the effect of which decreases as the frequency is raised and the impedance of the decoupling condenser falls. By correct proportioning of the bias resistor and by-pass condenser the increase in gain at high frequencies may be used to offset the fall in gain due to the capacitative shunt across the load resistor.

The circuit constants are not so readily calculable as for anode compensation, as a set of characteristics with a number of values of cathode bias resistor is required, and then suitable values have to be selected by trial and error. It has been found preferable to determine the proper values of cathode resistor and by-pass condenser by experiment, bearing in mind that the more compensation required the higher must be the cathode resistor to increase the feed-back factor. The by-pass condenser generally has a value between 200 and 1000 pF.

Two sets of curves are attached showing the performance of the 6CH6 as a cathode compensated amplifier. No. 307·316 shows the performance with a load of 2·2 kΩ shunted by approximately 15 pF and 25 pF, and No. 307·315 shows the performance with a load of 5 kΩ and similar values of capacitative shunt.

In some cases, in order to obtain sufficient feed-back to reach the desired upper frequency limit, the cathode resistor has to be of such a high value that the bias is too high for optimum working. This can be overcome by supplying a small positive bias voltage in opposition obtained from a potential divider from HT to grid and via the grid leak to earth. This is illustrated for condition 2 on Curve No. 307·315.

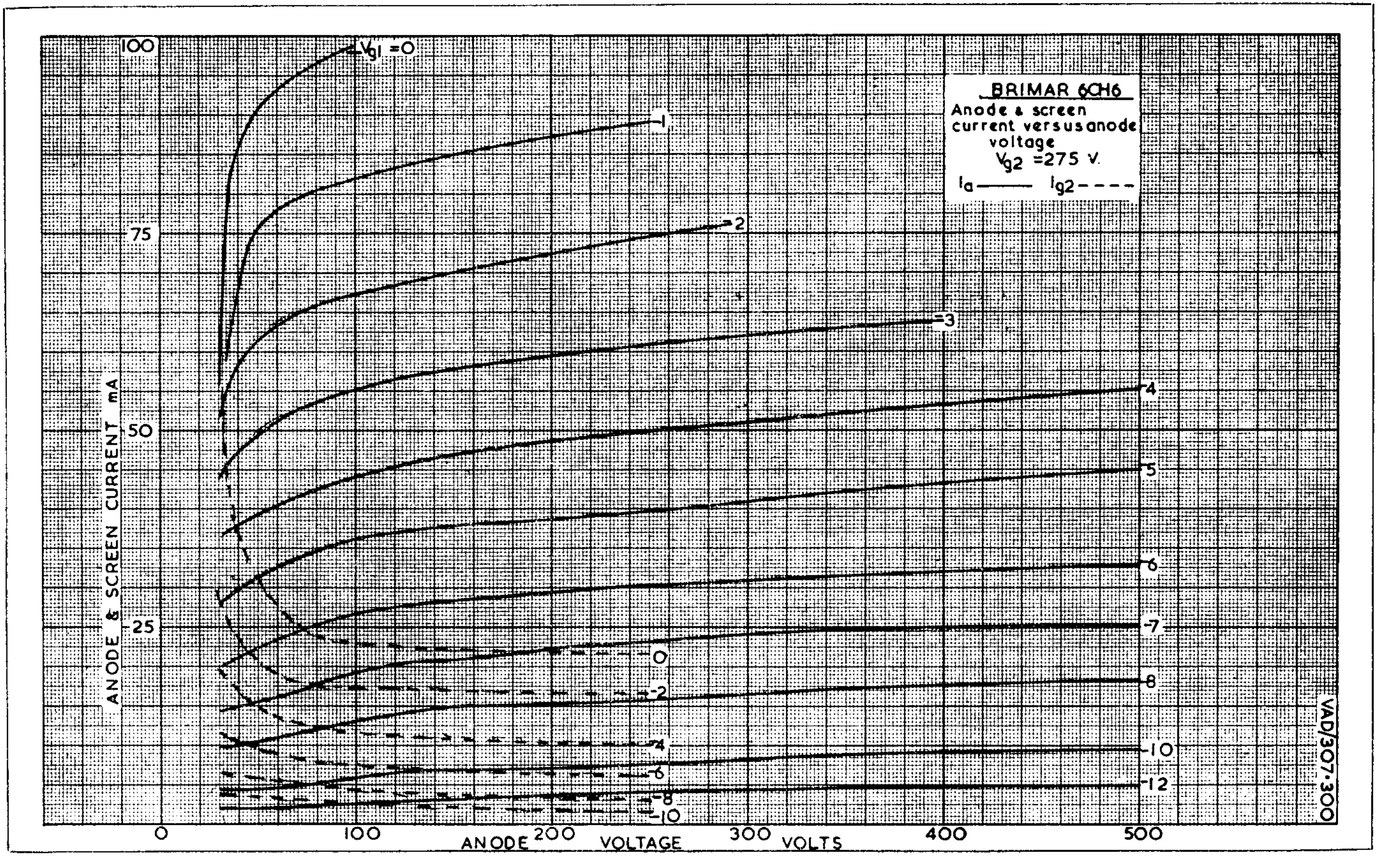
Cathode compensation gives a better low frequency response than anode compensation due to the constant degeneration at low frequencies. The cathode by-pass condenser used with anode compensation, however large, cannot provide effective decoupling at frequencies below 100 c/s.

As a result of the degeneration the cathode compensated amplifier suffers from the disadvantage of relatively low gain. The available output voltage is the same as for anode compensation, but a larger input voltage is required to generate it.

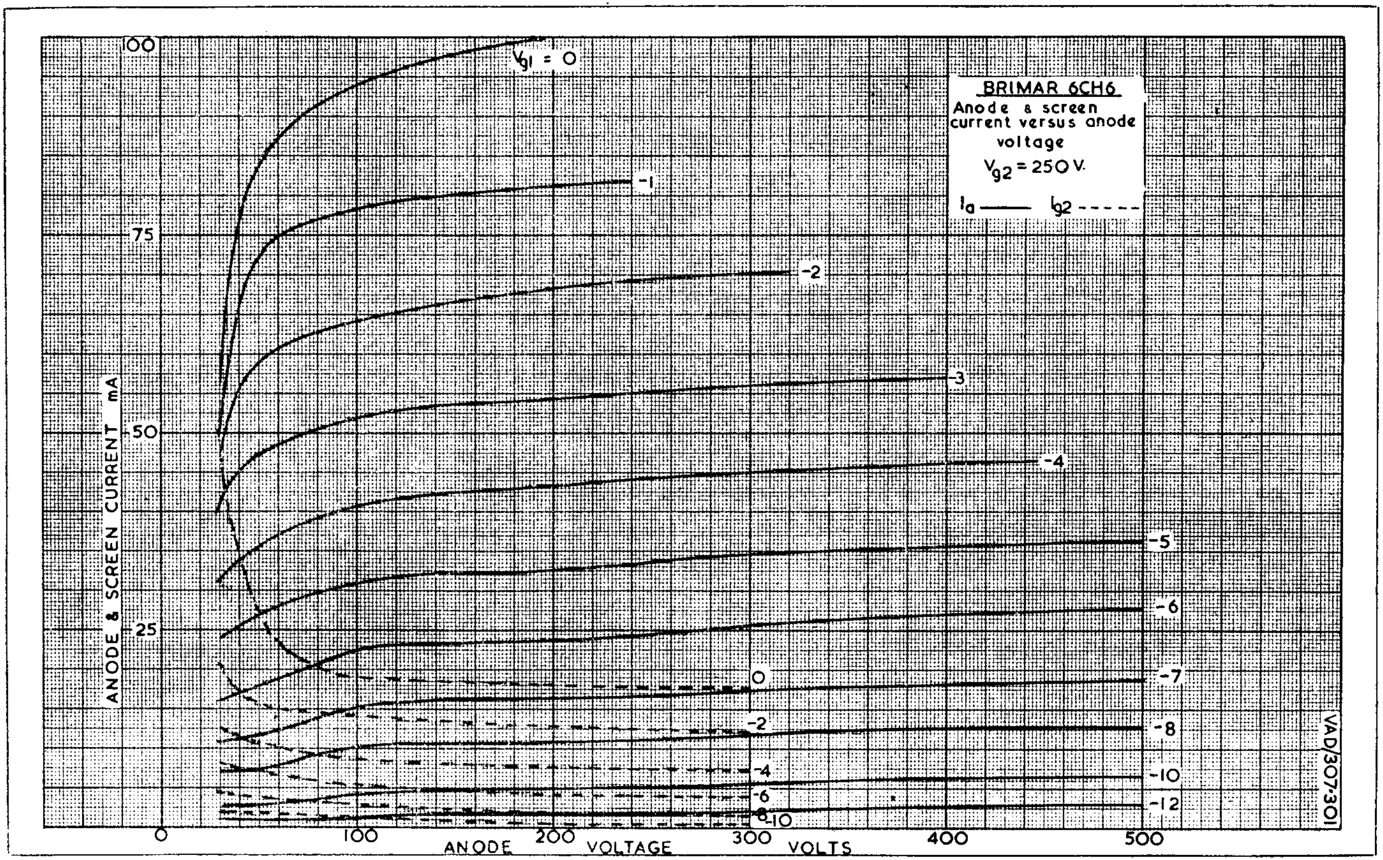
7.0 Cathode Follower: Due to its high slope the 6CH6 is very suitable for a cathode follower stage where a low output impedance is required. Triode connected, the output impedance varies between 60 and 70 ohms depending on the value of cathode resistor employed. With a 250 volt HT supply the cathode resistor should not be less than 100 ohms as the bias would then be insufficient. When a higher value of cathode resistor is used the grid return should be tapped down it to provide the correct operating bias.

8.0 Positive Grid Characteristics: The Curve No. 307·317 shows the characteristics of the 6CH6 with the control grid positive. These curves are useful if the valve is to be used as a pulse modulator or similar application where the control grid is driven positive, as it enables peak anode, screen and grid current to be approximated.

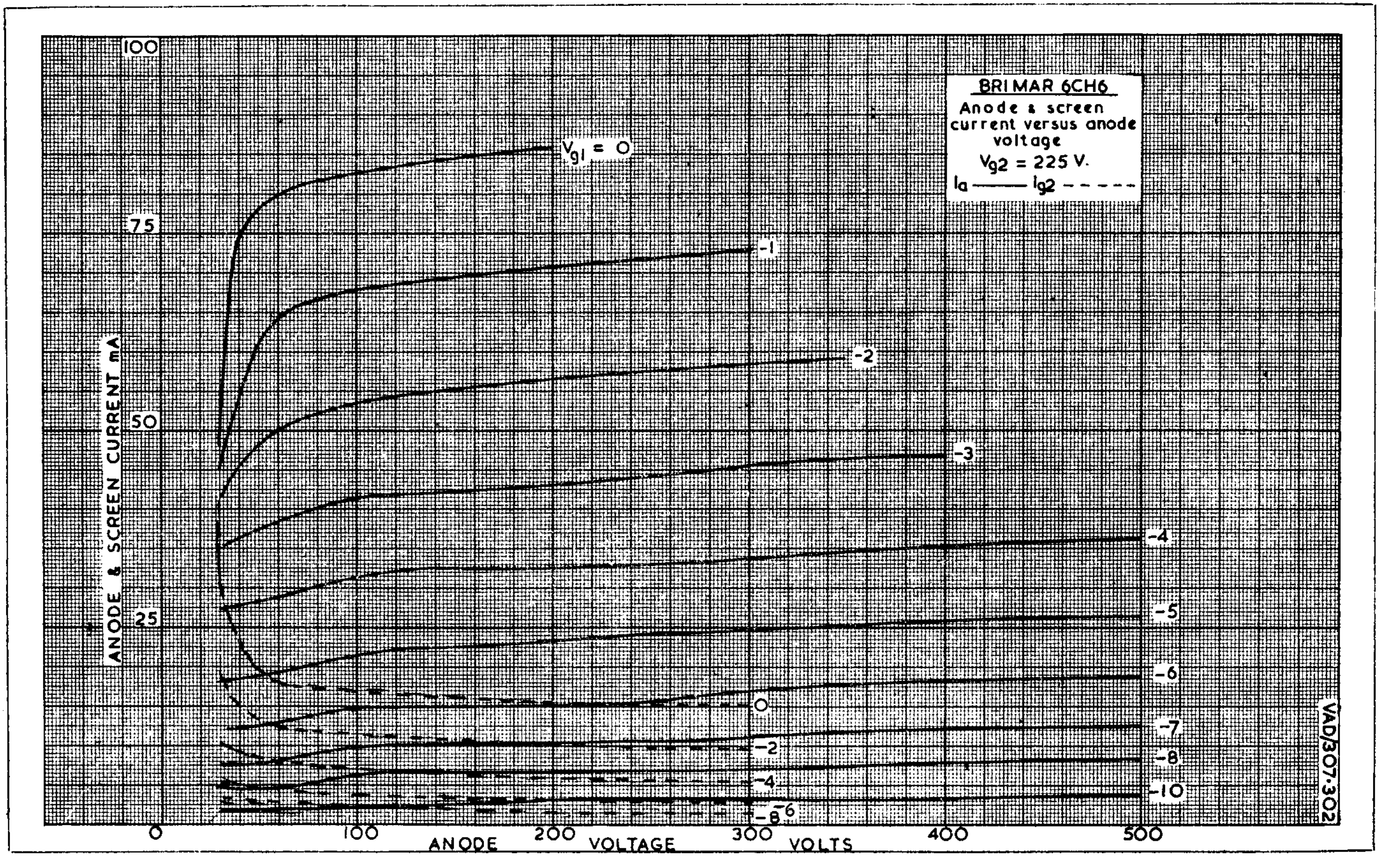
When using the valve with a positively pulsed grid care must be taken not to exceed the ratings given in paragraph 3.4, in particular attention must be paid to the note on grid dissipation.

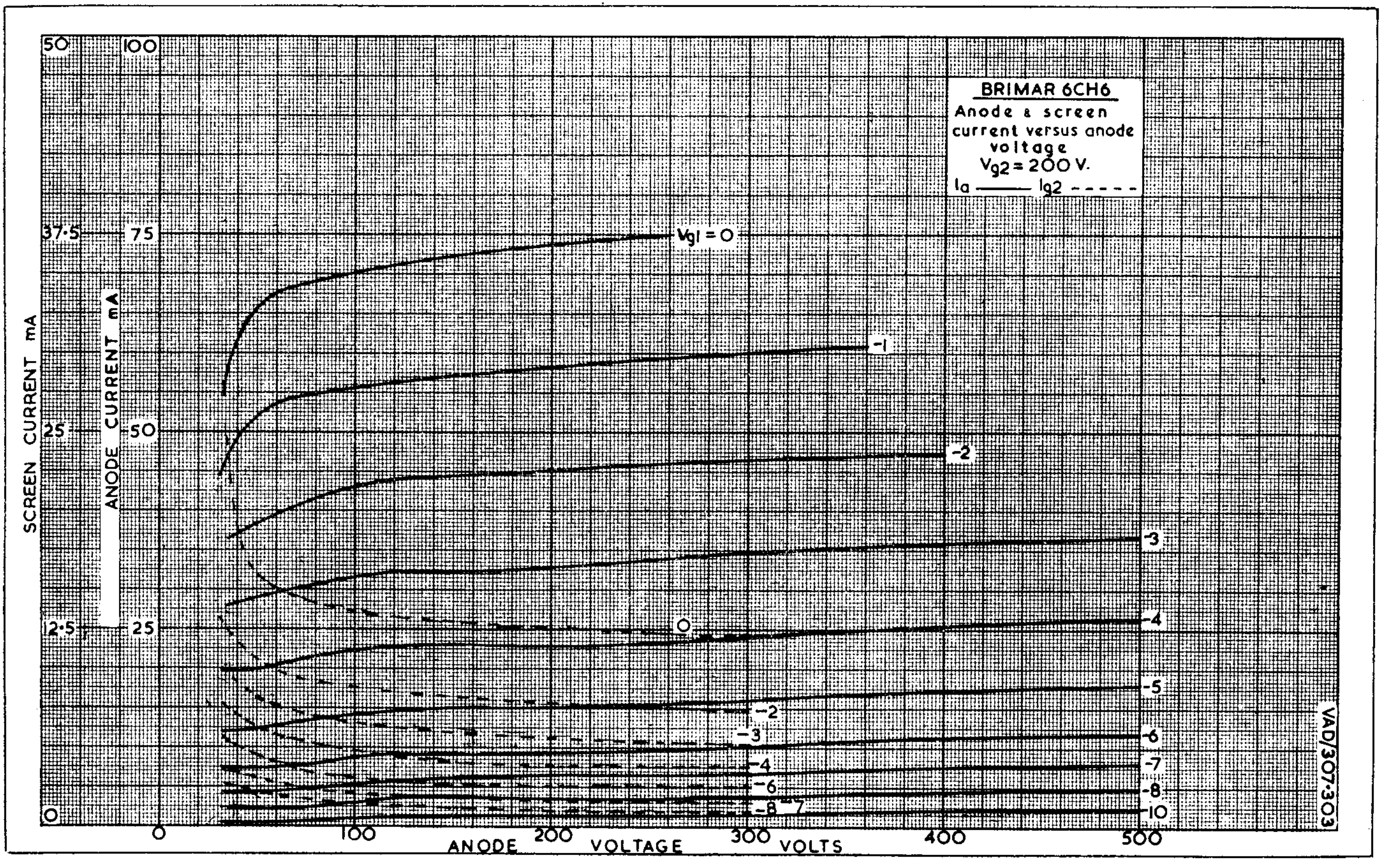


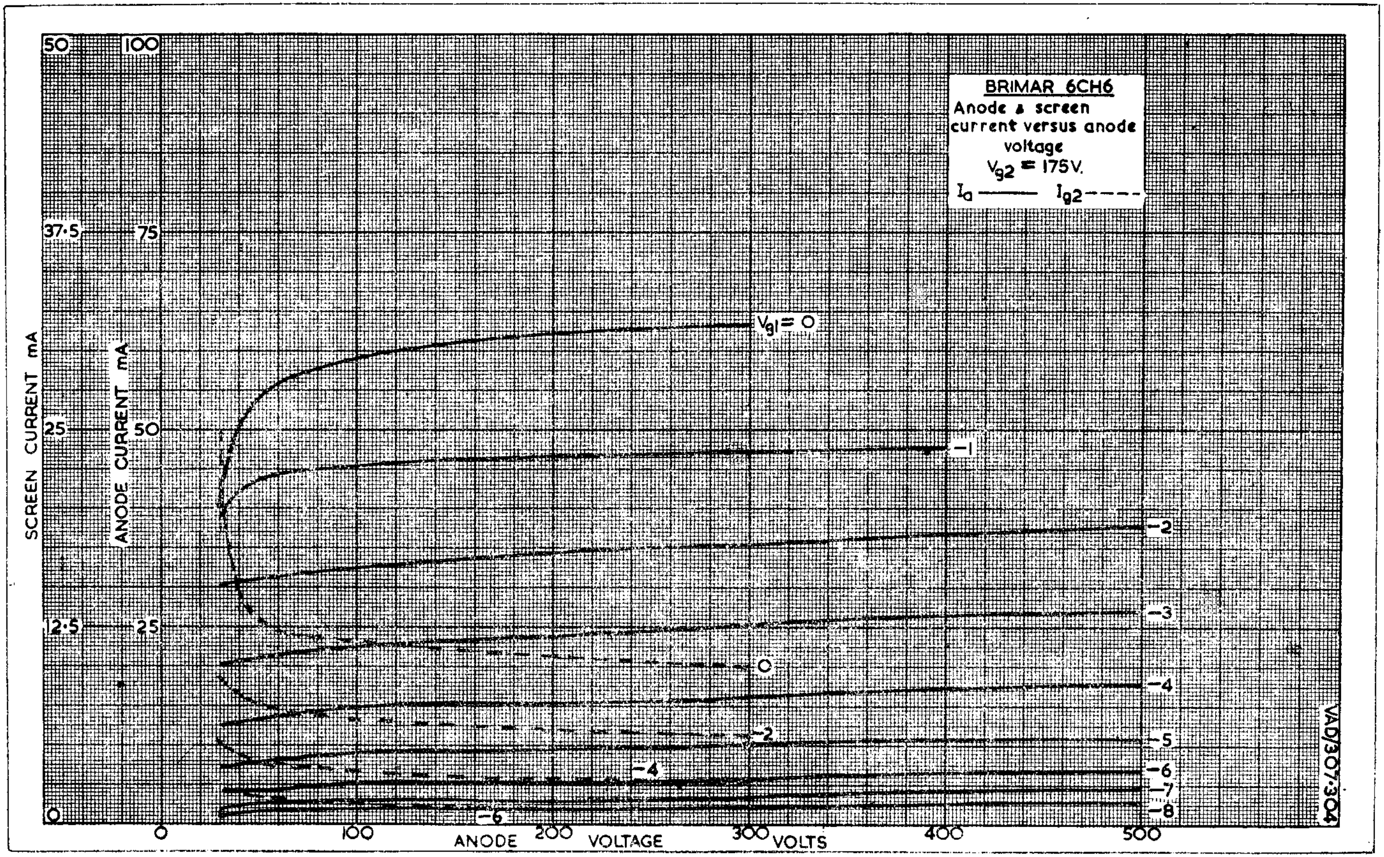
BRIMAR 6CH6
Anode & screen current versus anode voltage
V_{g2} =275 V.
I_a ——— I_{g2} - - - -
V_{g1} =0
-1
-2
-3
-4
-5
-6
-7
-8
-10
-12
0
-2
-4
-6
-8
-10
100
75
50
25
ANODE & SCREEN CURRENT mA
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VAD/307·300



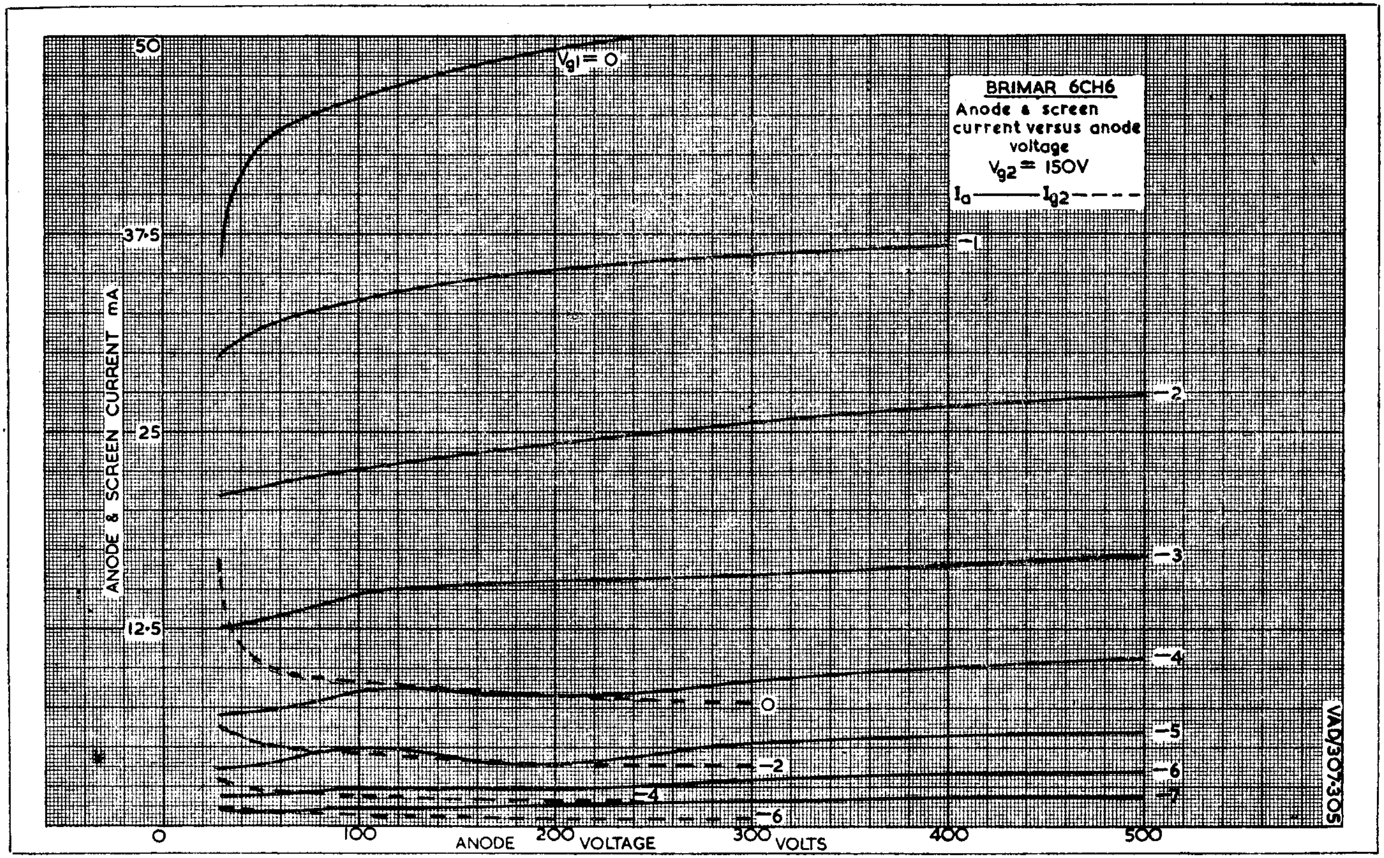
BRIMAR 6CH6
Anode & screen current versus anode voltage
$V_{g2} = 250$ V.
I_a ——— I_{g2} - - - - -
$V_{g1} = 0$
-1
-2
-3
-4
-5
-6
-7
-8
-10
-12
0
-2
-4
-6
-8
-10
100
75
50
25
ANODE & SCREEN CURRENT mA
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VAD/307·301


BRIMAR 6CH6
Anode & screen current versus anode voltage
Vg2 = 225 V.
Ia ——— Ig2 - - - - -
Vg1 = 0
-1
-2
-3
-4
-5
-6
-7
-8
-10
0
-2
-4
-6
-8
100
75
50
25
ANODE & SCREEN CURRENT mA
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VAD/307·302

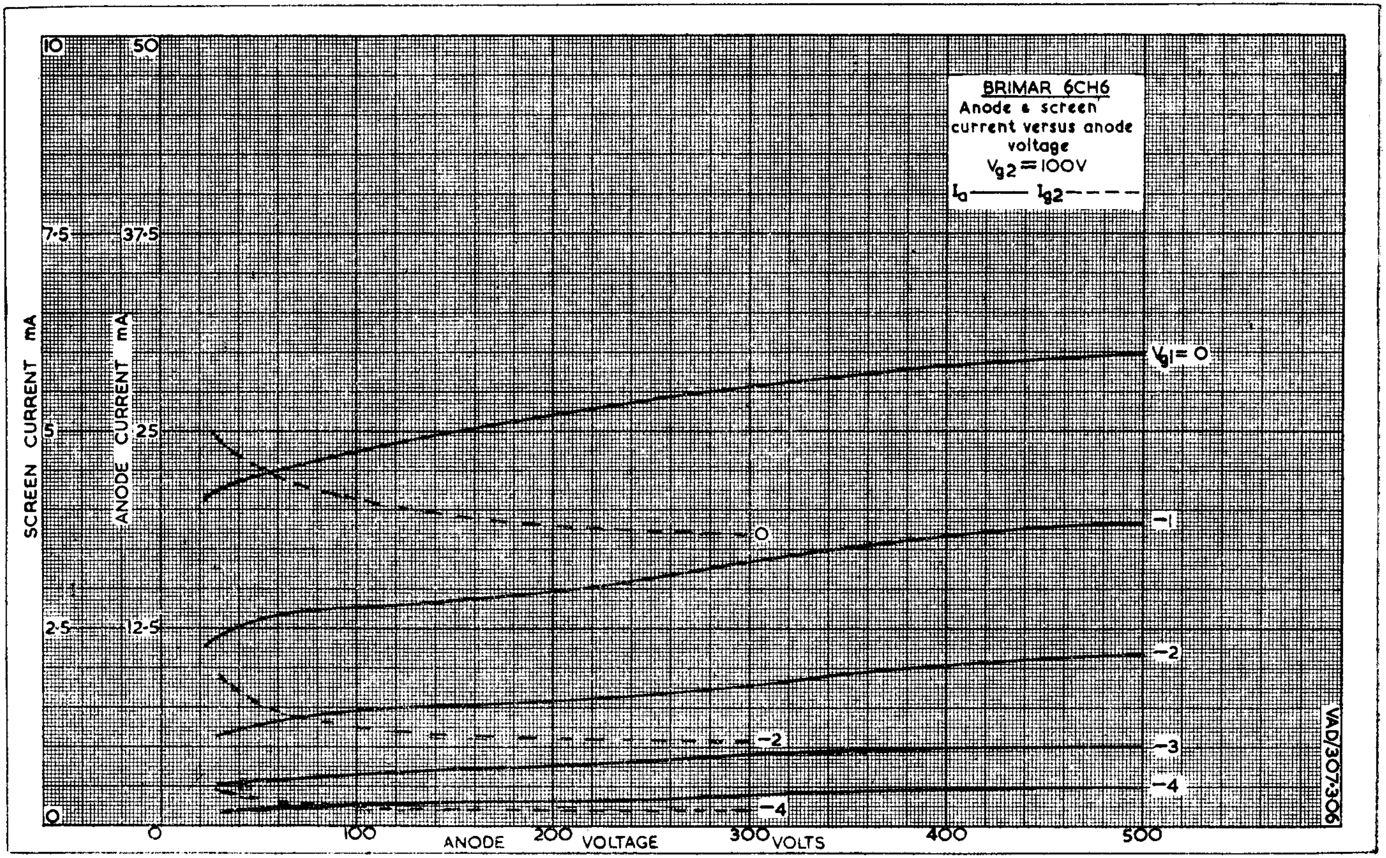

BRIMAR 6CH6
Anode & screen current versus anode voltage
Vg2 = 200 V.
Ia —— Ig2 - - - - -
Vg1 = 0
-1
-2
-3
-4
-5
-6
-7
-8
-10
0
-2
-3
-4
-6
-8
-7
VAD/307·303
SCREEN CURRENT mA
ANODE CURRENT mA
ANODE VOLTAGE VOLTS
50
37·5
25
12·5
0
100
75
50
25
0
100
200
300
400
500



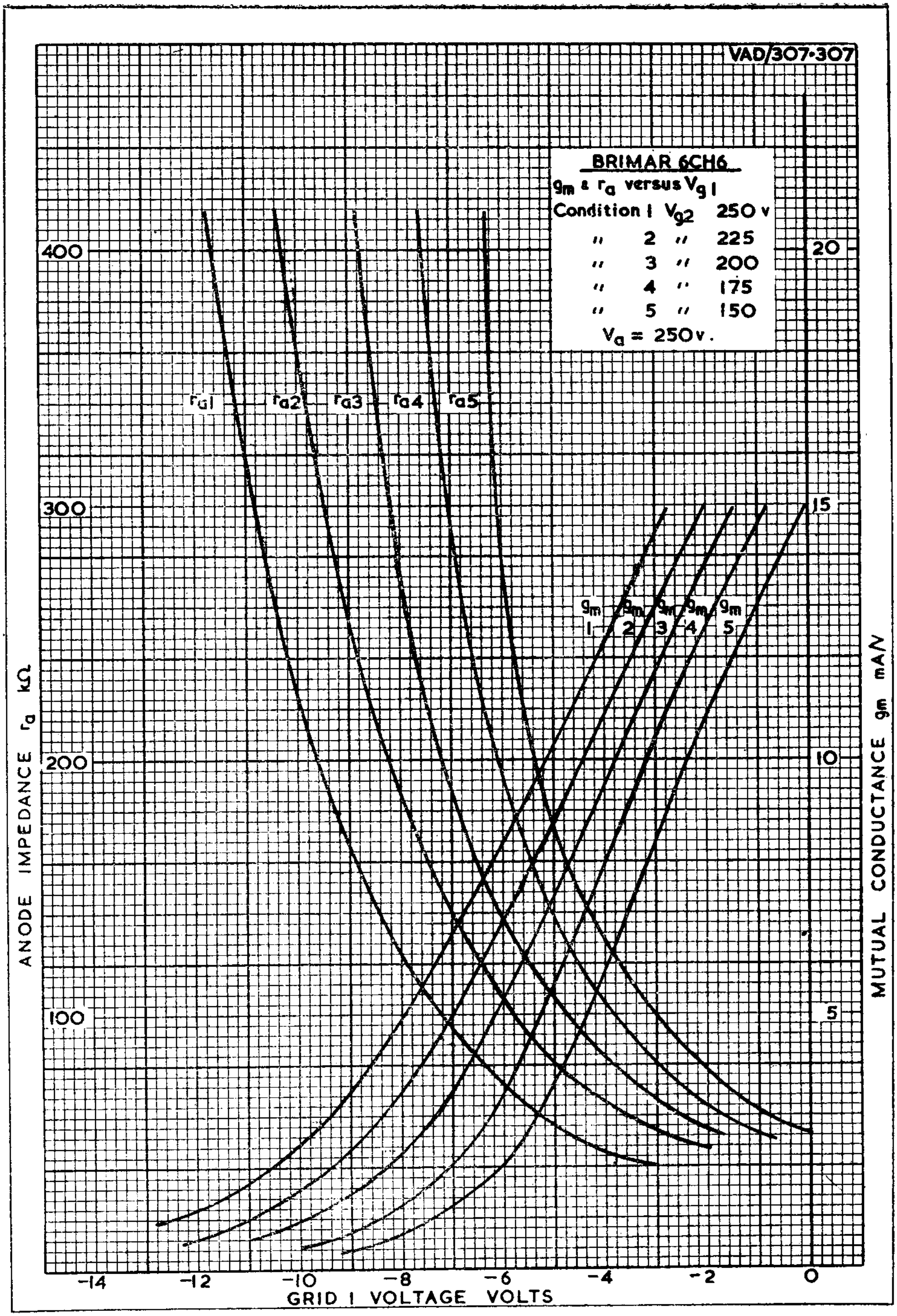
BRIMAR 6CH6
Anode & screen current versus anode voltage
V_{g2} = 175V.
I_a ——— I_{g2} - - - -
V_{g1} = 0
-1
-2
-3
-4
-5
-6
-7
-8
0
-2
-4
-6
SCREEN CURRENT mA
ANODE CURRENT mA
ANODE VOLTAGE VOLTS
50
37·5
25
12·5
100
75
50
25
0
100
200
300
400
500
VAD/307·304



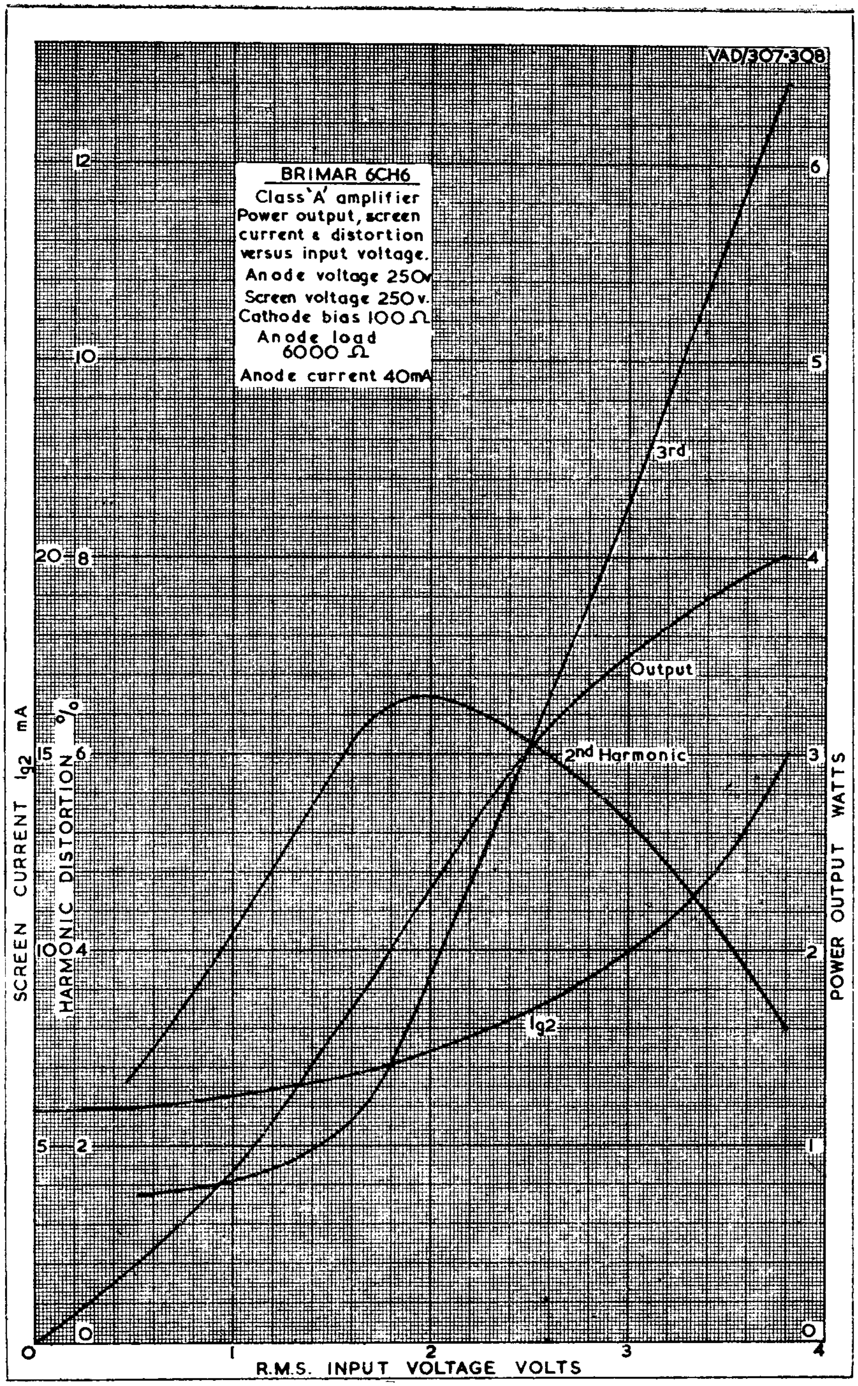
BRIMAR 6CH6
Anode & screen current versus anode voltage
V_{g2} = 150V
I_a ——— I_{g2} - - - -
V_{g1} = 0
−1
−2
−3
−4
−5
−6
−7
0
−2
−4
−6
ANODE & SCREEN CURRENT mA
50
37·5
25
12·5
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VAD/307·305



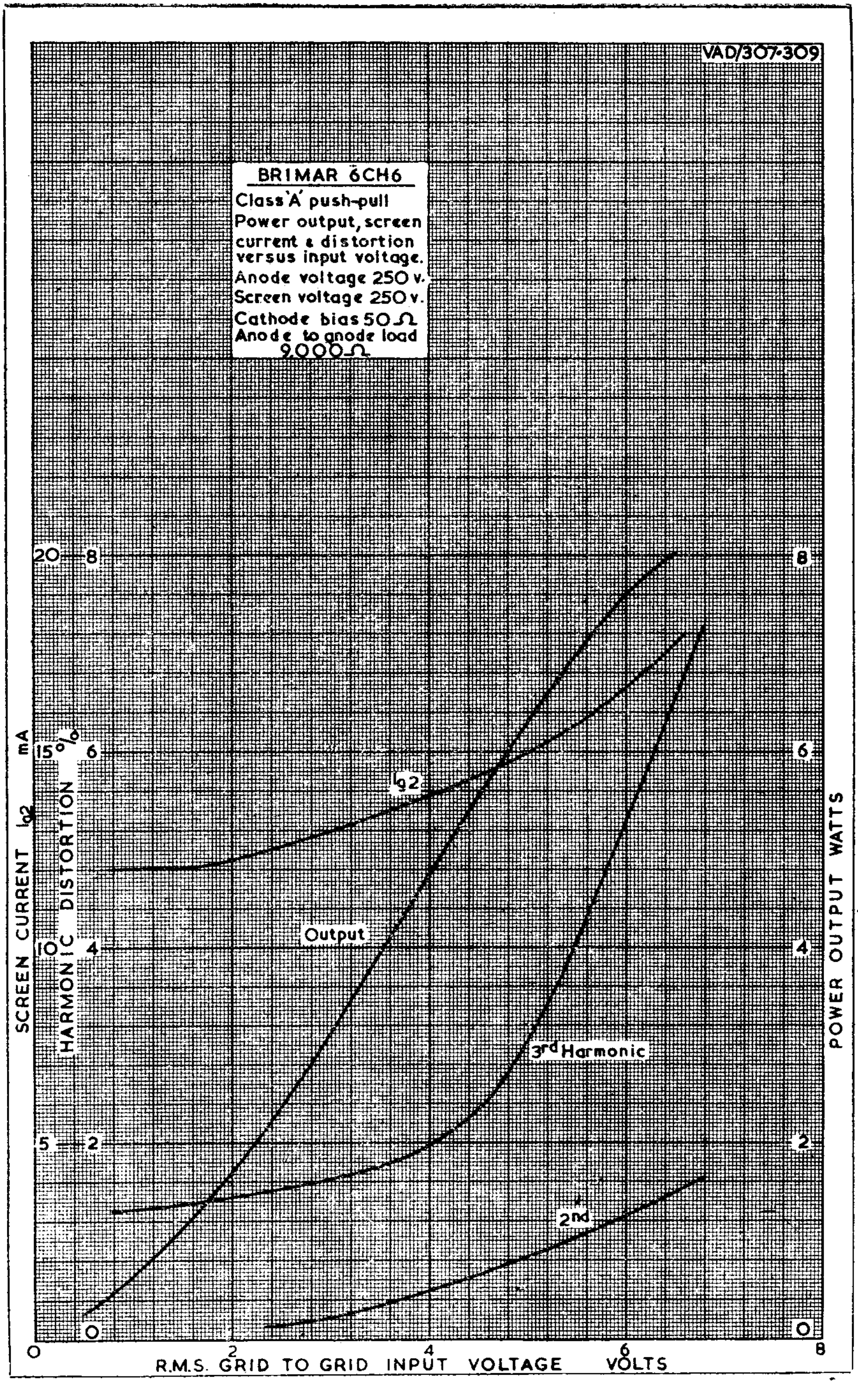
BRIMAR 6CH6
Anode & screen current versus anode voltage
Vg2 = 100V
Ia —— Ig2 - - - -
Vg1 = 0
−1
−2
−3
−4
0
−2
−4
SCREEN CURRENT mA
ANODE CURRENT mA
10
7·5
5
2·5
0
50
37·5
25
12·5
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VAD/307·306



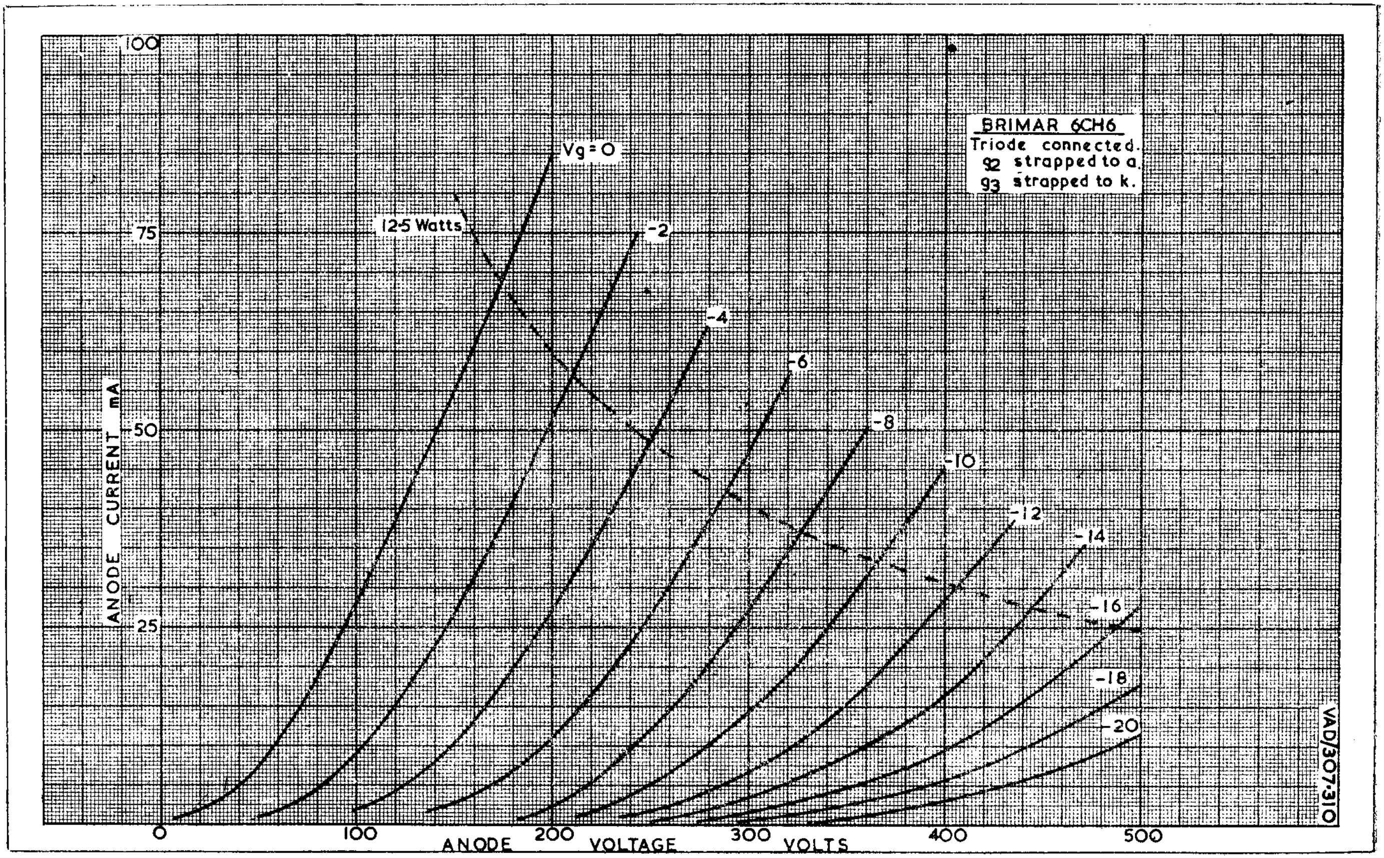
VAD/307·307
BRIMAR 6CH6
gm & ra versus Vg1
Condition 1 Vg2 250 v
" 2 " 225
" 3 " 200
" 4 " 175
" 5 " 150
Va = 250v.
ra1
ra2
ra3
ra4
ra5
gm 1
gm 2
gm 3
gm 4
gm 5
400
300
200
100
20
15
10
5
−14
−12
−10
−8
−6
−4
−2
0
ANODE IMPEDANCE ra kΩ
MUTUAL CONDUCTANCE gm mA/V
GRID 1 VOLTAGE VOLTS

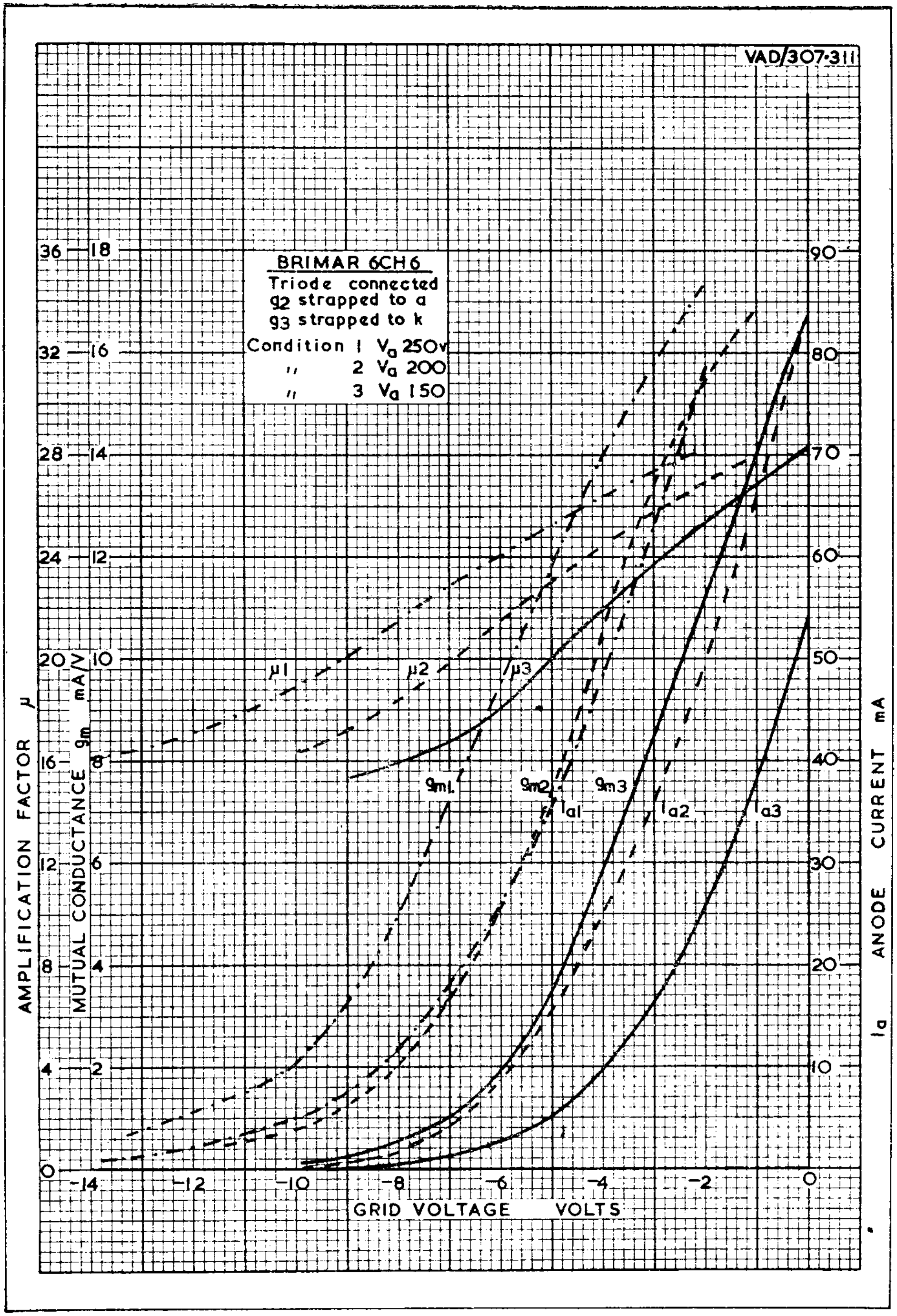


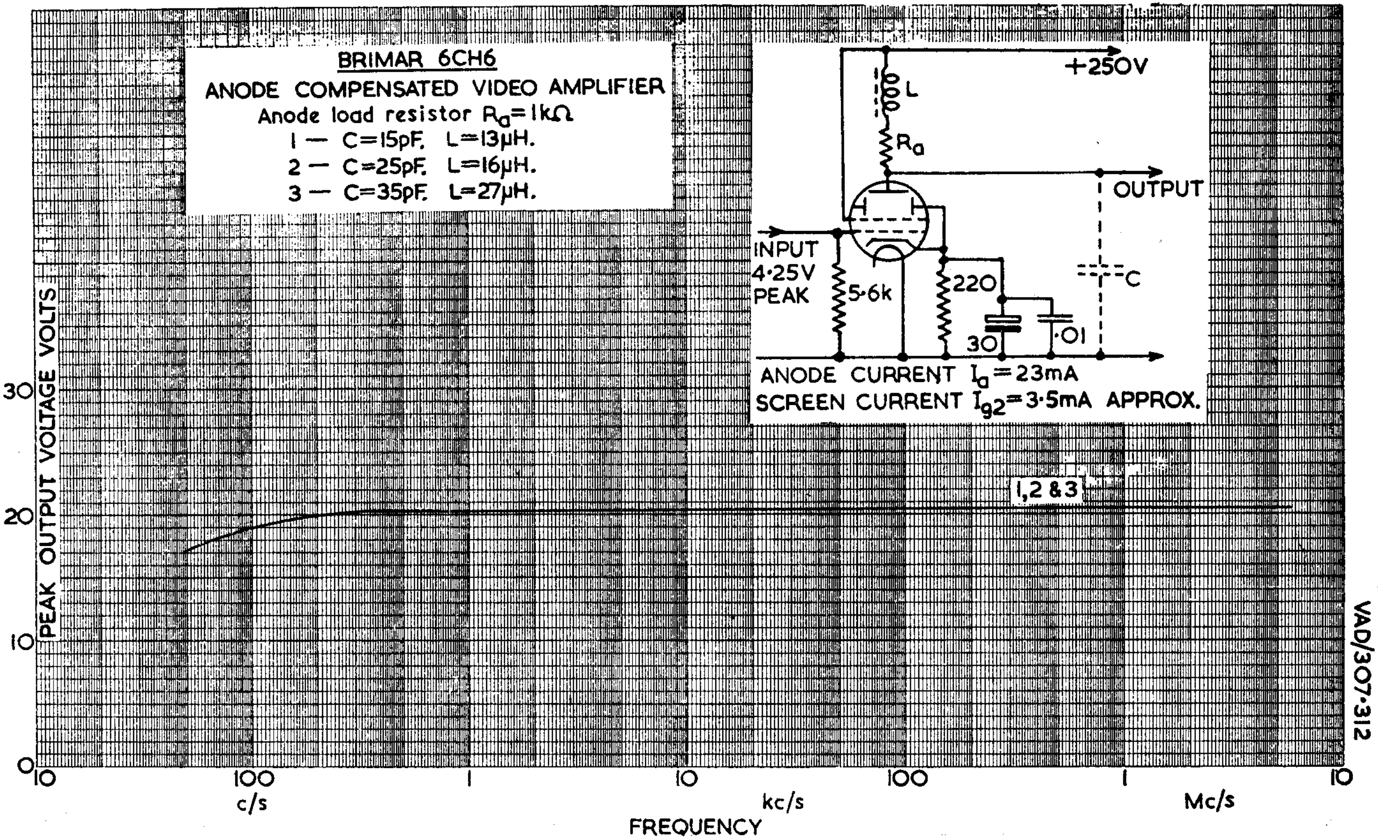
VAD/307·308
BRIMAR 6CH6
Class 'A' amplifier
Power output, screen current & distortion versus input voltage.
Anode voltage 250v
Screen voltage 250v.
Cathode bias 100 Ω
Anode load 6000 Ω
Anode current 40mA
3rd
Output
2nd Harmonic
Ig2
SCREEN CURRENT Ig2 mA
HARMONIC DISTORTION %
POWER OUTPUT WATTS
R.M.S. INPUT VOLTAGE VOLTS



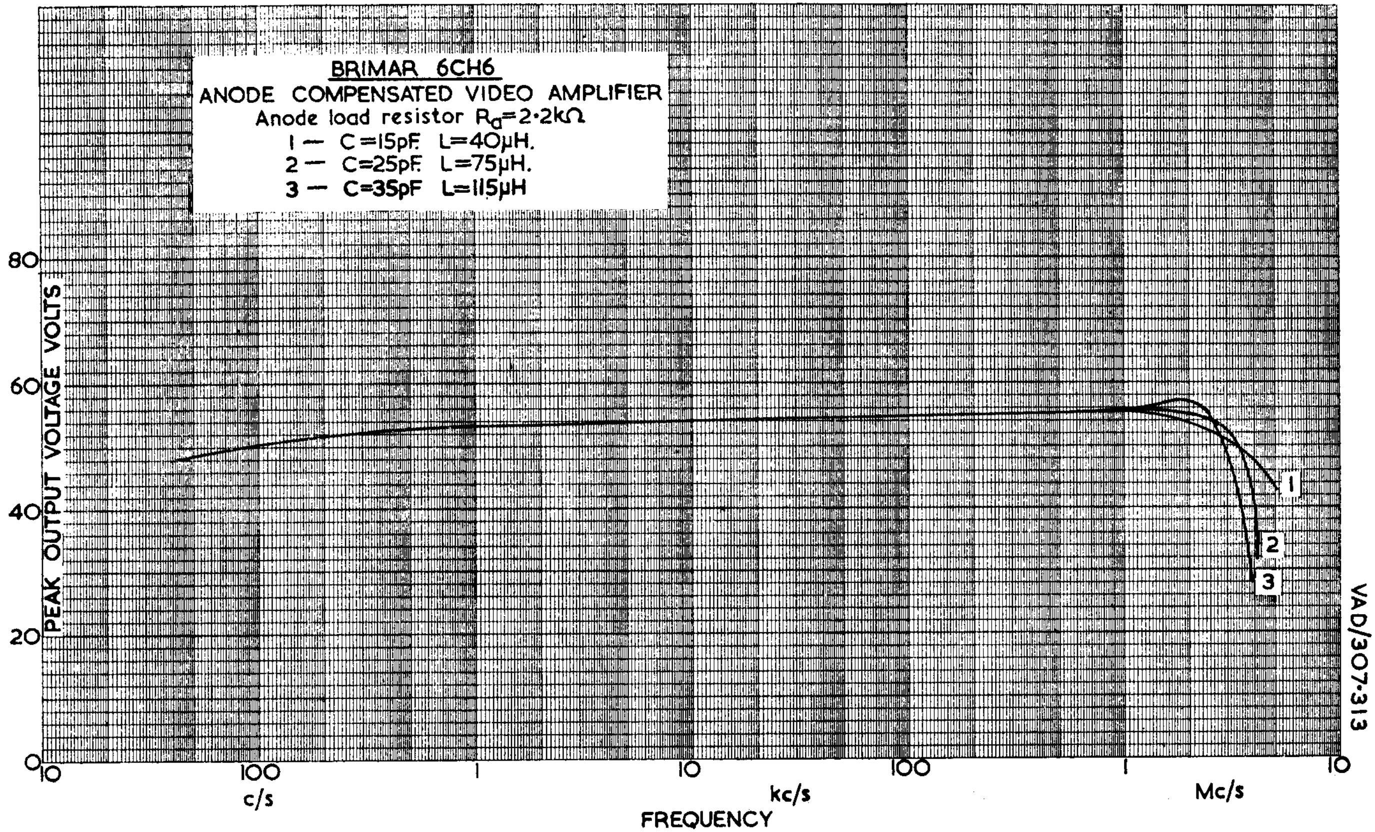
VAD/307-309
BRIMAR 6CH6
Class 'A' push-pull
Power output, screen current & distortion versus input voltage.
Anode voltage 250 v.
Screen voltage 250 v.
Cathode bias 50 Ω
Anode to anode load 9000 Ω
SCREEN CURRENT Ig2 mA
HARMONIC DISTORTION %
POWER OUTPUT WATTS
R.M.S. GRID TO GRID INPUT VOLTAGE VOLTS
Ig2
Output
3rd Harmonic
2nd


BRIMAR 6CH6
Triode connected.
g2 strapped to a.
g3 strapped to k.
Vg=0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
12·5 Watts
ANODE CURRENT mA
100
75
50
25
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VAD/307·310

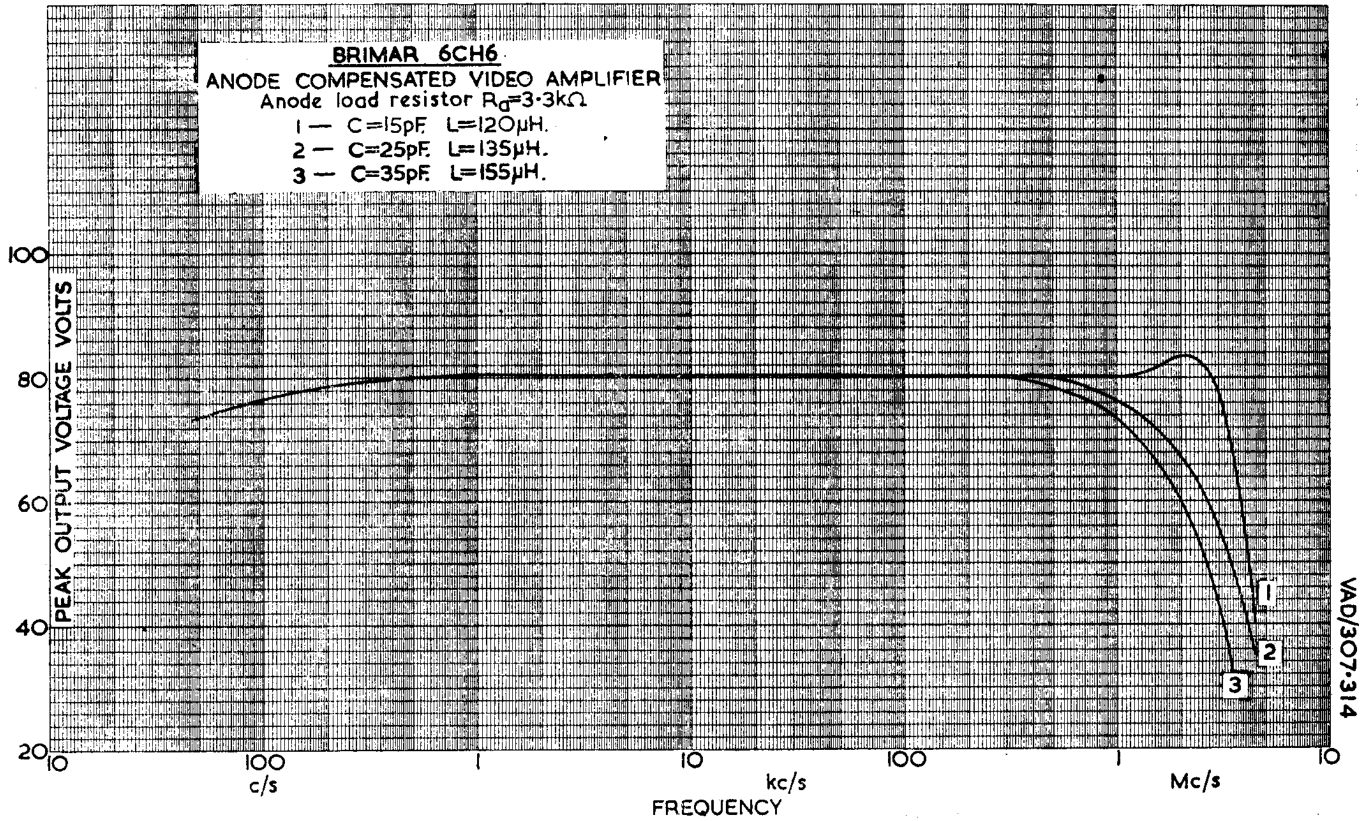

VAD/307·311
BRIMAR 6CH6
Triode connected
g2 strapped to a
g3 strapped to k
Condition 1 Va 250v
" 2 Va 200
" 3 Va 150
AMPLIFICATION FACTOR μ
MUTUAL CONDUCTANCE gm mA/V
ANODE CURRENT mA
Ia
GRID VOLTAGE VOLTS
μ1
μ2
μ3
gm1
gm2
gm3
Ia1
Ia2
Ia3
36
32
28
24
20
16
12
8
4
0
18
16
14
12
10
8
6
4
2
90
80
70
60
50
40
30
20
10
-14
-12
-10
-8
-6
-4
-2
0

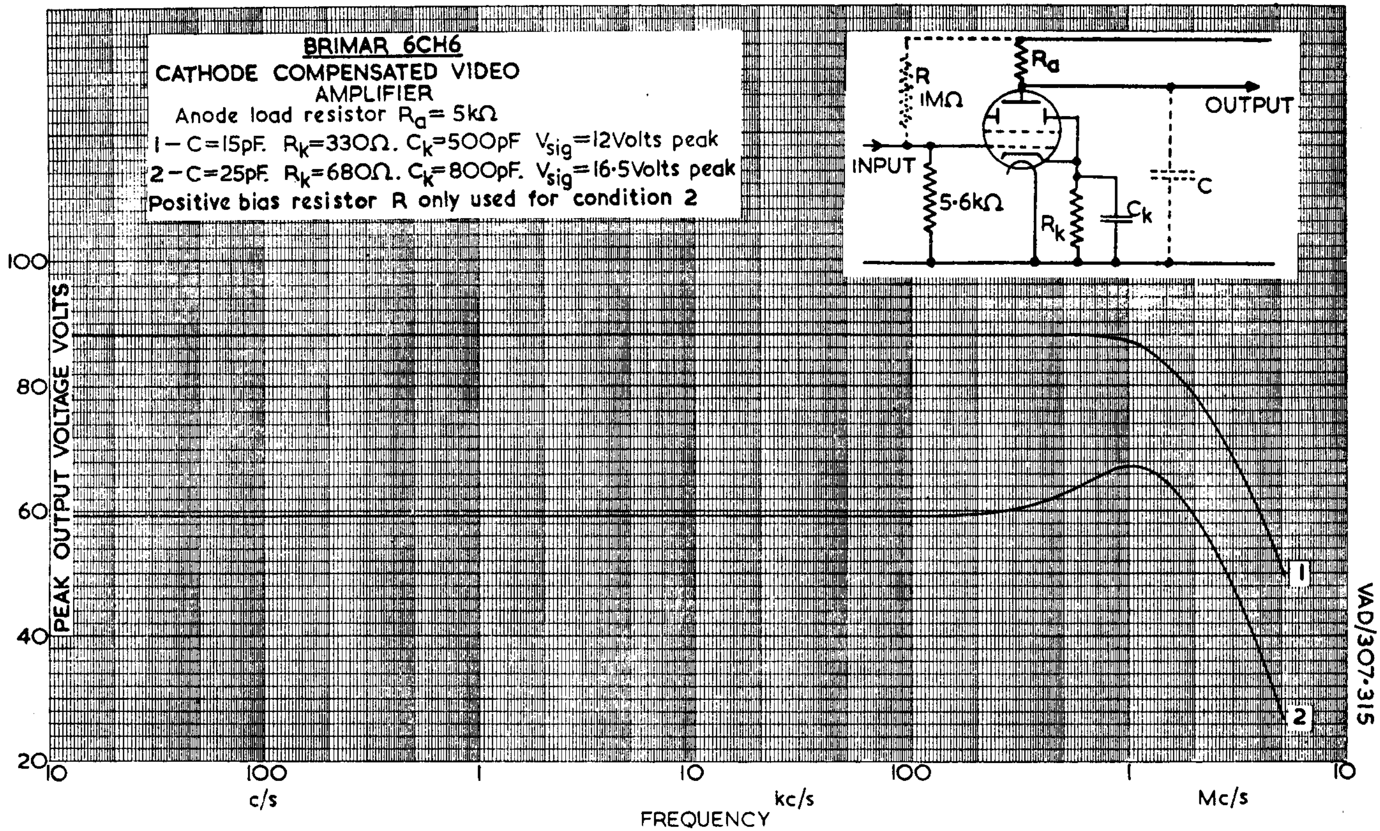


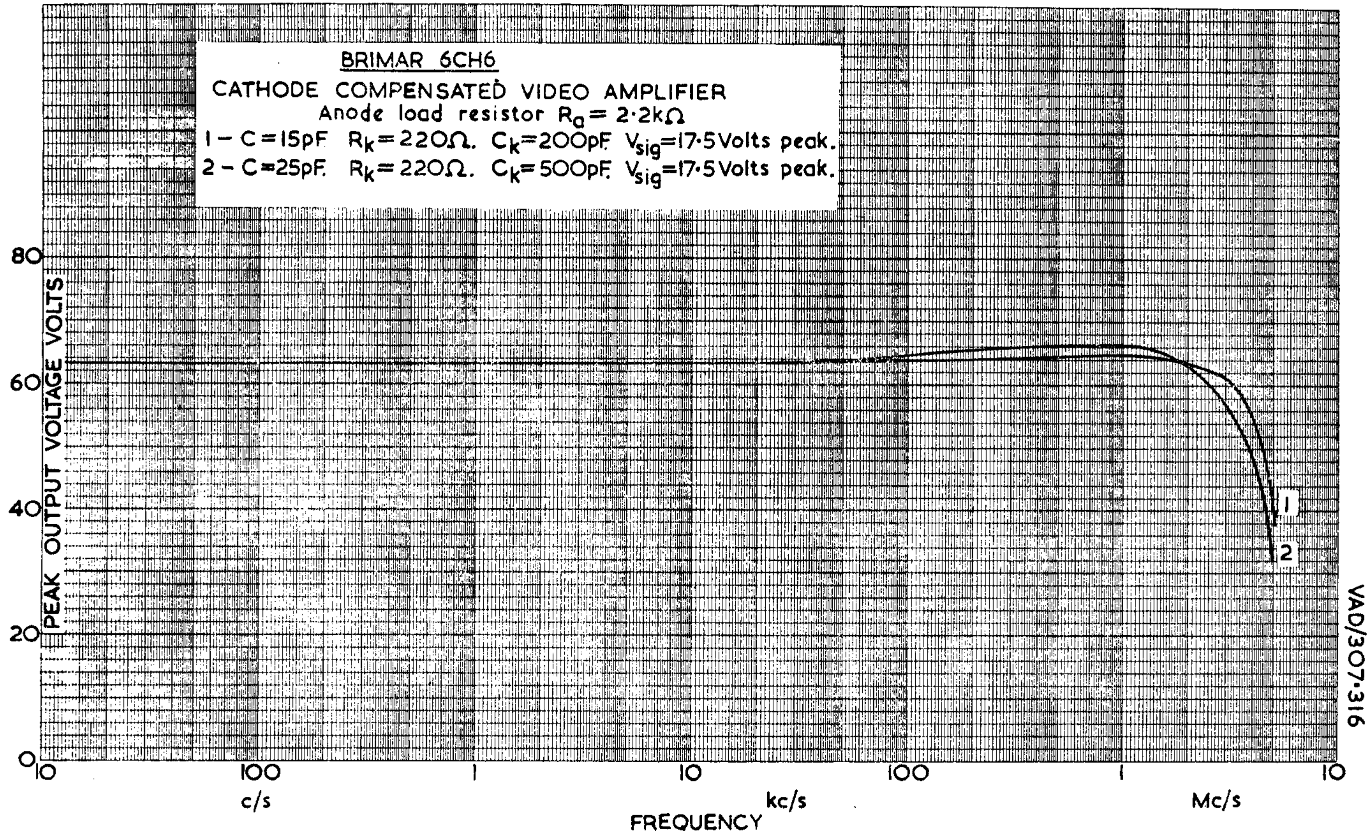
BRIMAR 6CH6
ANODE COMPENSATED VIDEO AMPLIFIER
Anode load resistor Ra=1kΩ
1 — C=15pF. L=13μH.
2 — C=25pF. L=16μH.
3 — C=35pF. L=27μH.
+250V
L
Ra
OUTPUT
INPUT
4·25V
PEAK
5·6k
220
30
·01
C
ANODE CURRENT Ia=23mA
SCREEN CURRENT Ig2=3·5mA APPROX.
1,2 & 3
PEAK OUTPUT VOLTAGE VOLTS
0
10
20
30
10
100
c/s
1
10
kc/s
100
1
Mc/s
10
FREQUENCY
VAD/307·312



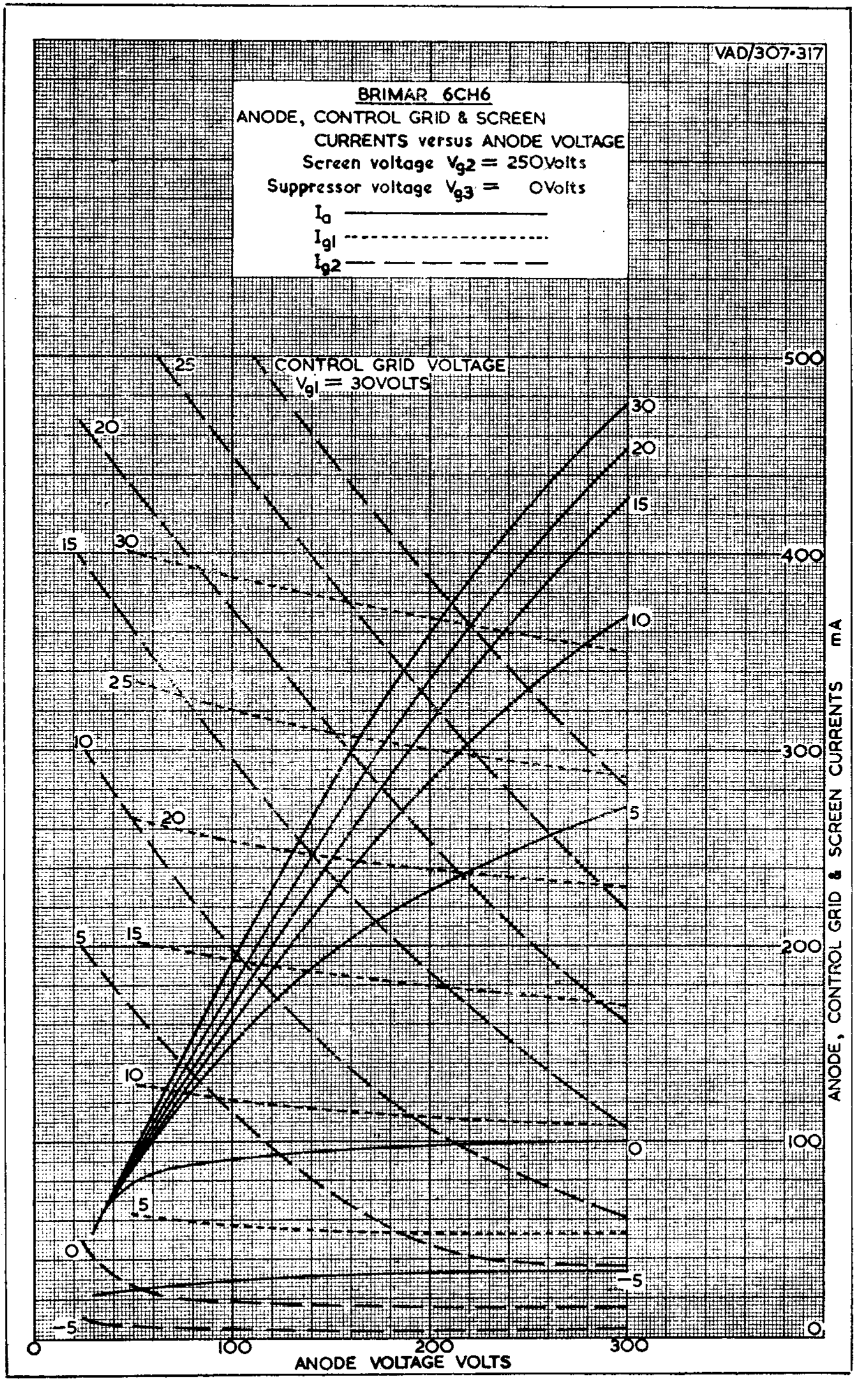
BRIMAR 6CH6
ANODE COMPENSATED VIDEO AMPLIFIER
Anode load resistor Ra=2·2kΩ
1 — C=15pF. L=40μH.
2 — C=25pF. L=75μH.
3 — C=35pF L=115μH
PEAK OUTPUT VOLTAGE VOLTS
80
60
40
20
0
10
100
1
10
100
1
10
c/s
kc/s
Mc/s
FREQUENCY
1
2
3
VAD/307-313


BRIMAR 6CH6
ANODE COMPENSATED VIDEO AMPLIFIER
Anode load resistor Ra=3·3kΩ
1 — C=15pF L=120μH.
2 — C=25pF L=135μH.
3 — C=35pF L=155μH.
PEAK OUTPUT VOLTAGE VOLTS
100
80
60
40
20
10
100
c/s
1
10
kc/s
100
1
Mc/s
10
FREQUENCY
1
2
3
VAD/307·314


BRIMAR 6CH6
CATHODE COMPENSATED VIDEO AMPLIFIER
Anode load resistor Ra = 5kΩ
1 – C=15pF. Rk=330Ω. Ck=500pF Vsig=12Volts peak
2 – C=25pF. Rk=680Ω. Ck=800pF. Vsig=16·5Volts peak
Positive bias resistor R only used for condition 2
R
1MΩ
Ra
OUTPUT
INPUT
5·6kΩ
Rk
Ck
C
PEAK OUTPUT VOLTAGE VOLTS
100
80
60
40
20
10
100
1
10
100
1
10
c/s
kc/s
Mc/s
FREQUENCY
1
2
VAD/307·315



BRIMAR 6CH6
CATHODE COMPENSATED VIDEO AMPLIFIER
Anode load resistor $R_a = 2{\cdot}2k\Omega$
1 – C = 15pF $R_k = 220\Omega$. $C_k = 200pF$ $V_{sig} = 17{\cdot}5$ Volts peak.
2 – C = 25pF $R_k = 220\Omega$. $C_k = 500pF$ $V_{sig} = 17{\cdot}5$ Volts peak.
PEAK OUTPUT VOLTAGE VOLTS
80
60
40
20
0
10
100
1
10
100
1
10
c/s
kc/s
Mc/s
FREQUENCY
1
2
VAD/307·316



VAD/307·317
BRIMAR 6CH6
ANODE, CONTROL GRID & SCREEN
CURRENTS versus ANODE VOLTAGE
Screen voltage V_{g2} = 250 Volts
Suppressor voltage V_{g3} = 0 Volts
I_a
I_{g1}
I_{g2}
CONTROL GRID VOLTAGE
V_{g1} = 30 VOLTS
ANODE VOLTAGE VOLTS
ANODE, CONTROL GRID & SCREEN CURRENTS mA

BRIMAR

RECEIVING VALVE
12AH8

APPLICATION REPORT VAD/520.2

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

Issued March, 1952

1.0 INTRODUCTION: The Brimar 12AH8 is a miniature, Noval based, triode-heptode frequency changer intended for use in all wave broadcast and communication receivers. Particular attention has been paid to the attainment of high conversion conductance and impedance and good oscillator performance. The valve has been designed to operate from either a 250 volt or a 100 volt HT rail, and may be used in both AC and AC/DC type equipment. A centre tapped heater is provided so that the valve may be operated at 12·6 volts 0·15 ampere or 6·3 volts 0·3 ampere.

This report contains characteristics of the valve and details of its uses as a frequency changer in superheterodyne receivers.

2.0 DESCRIPTION: The valve consists of two units mounted one above the other having common heater and cathode connections. The lower unit is the heptode mixer and the upper the triode oscillator. The triode grid is internally connected to grid 3 of the heptode. The whole is enclosed in a T6½ bulb and mounted on a standard B9A (Noval) nine pin base.

3.0 CHARACTERISTICS:

3.1 Cathode:	Indirectly heated	
	Voltage	6·3 or 12·6 volts
	Current	0·3 or 0·15 amperes
	Max. DC Heater to Cathode potential	250 volts
	Max. Cathode Current	17·5 mA
3.2 Dimensions:	Max. Overall Length	2-5/8 ins.
	Max. Diameter	7/8 in.
	Max. Seated Height	2-3/8 ins.
3.3 Base:	Type B9A (Noval) Nine Pin	

3.4 Basing Connections:

Pin 1 Screen $g_2 + g_4$
Pin 2 Heptode Control Grid g_{1h}
Pin 3 Cathode and Suppressor Grid $k + g_5$
Pin 4 Heater h
Pin 5 Heater h
Pin 6 Heptode Anode a_h
Pin 7 Triode Grid and Heptode Grid 3 $g_t + g_3$
Pin 8 Triode Anode a_t
Pin 9 Heater Centre Tap h_{tap}

3.5 Ratings:

HEPTODE SECTION:	
Max. Anode Voltage	300 volts
Max. Screen Voltage	125 volts
Max. Anode Dissipation	1·5 watts
Max. Screen Dissipation	1·25 watts
TRIODE SECTION:	
Max. Anode Voltage	150 volts
Max. Anode Dissipation	0·75 watts

3.6 Inter-electrode Capacitances (approx.) Measured with close fitting external shield:

RF Input $c_{g1h,\ all}$	5·0 pF
IF Output $c_{ah,\ all}$	8·0 pF
Triode Input	7·0 pF
Triode Output	2·5 pF
Heptode Grid to Heptode Anode	0·025 pF (max.)
Triode Grid to Triode Anode	1·2 pF
Control Grid to Triode Anode	0·1 pF
Control Grid to Triode Grid	0·2 pF

3.7 Characteristic Curves: Curves are attached to this report as follows:

I_{ah} and I_{g2+g4} versus V_{g1h} with V_{ah} 100 volts and various values of V_{g2+g4}	320·14
Ditto with V_{ah} 250 volts	320·15
Conversion Conductance and Impedance versus V_{g1h} with V_{ah} 100 volts and various values of V_{g2+g4}	320·16
Ditto with V_{ah} 250 volts	320·17
Conversion Conductance and Impedance versus I_{gt} with V_{ah} 100 volts and various values of V_{g2+g4}	320·18
Ditto with V_{ah} 250 volts	320·19
I_{ah} and I_{g2+g4} versus I_{gt} with V_{ah} 100 volts and various values of V_{g2+g4}	320·20
Ditto with V_{ah} 250 volts	320·21
I_{ah} and I_{g2+g4} versus V_{g3} with V_a 250 V_{g2+g4} 100 and various values of V_{g1h}	320·22
Ditto versus V_{g1h} with various values of V_{g3}	320·23
I_a/V_a Triode	320·24

4.0 TYPICAL OPERATION:

4.1 TYPICAL OPERATING CONDITIONS:

Heptode Anode Voltage V_{ah}	100	250	volts
Heptode Screen Voltage V_{g2+g4}	100	100	volts
Control Grid Voltage V_{g1h}	—3	—3	volts
Cathode Bias Resistor R_k	220	220	ohms
Triode Anode Supply Voltage $V_{at(b)}$	100	250	volts
Triode Anode Series Resistor R_{at}	0	27,000	ohms
Triode Anode Voltage V_{at}	100	100	volts
Heptode Anode Current I_{ah}	2·5	2·6	mA
Heptode Screen Current I_{g2+g4}	4·5	4·4	mA
Triode Grid Current I_{gt}	200	200	μA
Triode Grid Resistor R_{gt}	47	47	kΩ
Conversion Conductance g_c	0·52	0·55	mA/V
Control Grid Bias for $\frac{g_c}{100}$ V_{g1h}	—22	—22	volts
Conversion Impedance r_c	0·6	1·5	MΩ
Equivalent Noise Resistance (approx. r_{eq})	100	100	kΩ

4.11 TRIODE CHARACTERISTICS:

Anode Voltage V_a	100	volts
Grid Voltage V_g	0	volts
Anode Current I_a	14·6	mA
Anode Impedance r_a	4850	ohms
Mutual Conductance g_m	3·5	mA/V
Amplification Factor μ	17	

4.2 GENERAL RECOMMENDATIONS:

4.21 Triode Grid Current: The oscillator section of the 12AH8 has a relatively high mutual conductance so that normally there is no difficulty in obtaining adequate grid current. The optimum value of grid current is 200 μA and the coils should be designed so that an average valve operates at this value. At the weakest point of oscillation the grid current must not fall below 125 μA. Inspection of the Curves 320·18 and 320·19 shows that a rapid drop in conversion takes place below 150 μA grid current, and this region should be avoided if large variations in gain on production chassis are to be avoided.

It is desirable to place a maximum limit on oscillator grid current, as too high a value often leads to parasitic oscillations and, in particular, to tunable whistles due to the generation of oscillator harmonics. It is suggested that the oscillator grid current be held below 400 μA for these reasons.

If, due to the type of oscillator circuit used, a large variation in triode grid current is encountered over the tuning range, a low value resistor may be wired in series with either grid or anode directly to the valve holder tag to stabilise the feed back.

4.22 Application of A.V.C.: A.V.C. may be applied to the control grid, and its effect on the characteristics is shown in the curves. On 320·14 and 320·15 is shown the relation between anode and screen currents and A.V.C., and on 320·16 and 17 the effect of A.V.C. on the conversion conductance and impedance.

The DC resistance in the control grid circuit should be kept below 3MΩ. This is particularly important on the short waves as a high value grid leak increases the tendency for the control grid to draw current due to pick-up of the oscillator voltage through stray coupling or capacity within the valve.

In communication receivers it is best to operate the frequency changer without A.V.C., as its application causes a small amount of pulling of the oscillator frequency (Curve 320·31). If no RF amplifier exists before the frequency changer the bulk of the receiver noise originates in the mixer valve; running this at maximum gain reduces its noise level to a minimum.

4.23 Screen Voltage: The method of supplying the screen voltage has a great effect on the A.V.C. characteristics of the 12AH8. When the valve is operated from a 100 volt HT rail the screen is generally connected directly to this, or if any series resistance exists it is of low value purely for decoupling. Variations in the screen current due to the A.V.C. action then have no effect on the screen voltage, but if the screen supply is obtained by way of a dropping resistor from a higher voltage HT rail, the variations in screen current affect the screen voltage in such a way as partially to offset the A.V.C. action. The fall in screen current is accompanied by a rise in screen voltage which tends to maintain the level of anode current and conversion conductance. This effect is shown on graphs 320·15 and 320·17 where curves are given for operation with a series screen resistor. If a potential divider is used to derive the screen voltage the steady current drawn by the bottom resistor assists in stabilising the screen voltage. If both the frequency changer valve and IF amplifier valve have their screens fed through a common series resistor the A.V.C. control is extremely poor, as two valves are now opposing the A.V.C. action and assisting each other in the process. A common potential divider for the two valves, however, offers a solution which gives adequate A.V.C. control. On 320·28 are curves illustrating these effects, and the long cut-off tail of the sliding screen can be compared with that of the direct and potential divider supply. The curve showing the control when the potential divider is common to the frequency changer and IF amplifier includes the gain of the IF amplifier, whereas the other three curves are for the frequency changer alone.

Another reason why a common series screen resistor for the two valves is not recommended is because variations in the screen current of one valve necessarily affect the screen potential of both valves. Excessive variations in gain will then be experienced with valves with normal spread of screen current.

4.24 Methods of Bias: Bias for the control grid should be derived from a cathode bias resistor exclusive to the 12AH8. The practice of sharing a cathode bias resistor with another valve is not recommended as it makes the receiver gain too reliant on the total cathode current of the two valves.

Bias should not be obtained wholly from the contact potential of the A.V.C. diode as this is subject to very wide variations, in extreme cases being non-existent.

4.3 High Frequency Performance: The 12AH8 is very suitable as a frequency changer for broadcast type receivers in the V.H.F. 88 to 108 Mc/s band. Its signal to noise performance precludes its use from V.H.F. communication type equipment and television, but it has very definite possibilities for low and medium priced receivers for broadcast reception of FM or AM stations in the international V.H.F. band. Details of a suitable circuit and performance figures are given later in this report.

4.31 Input Impedance and Capacity: A curve showing the change of input impedance and capacity plotted against A.V.C. voltage at 90 Mc/s is given on 320·32. This indicates that it is undesirable to apply A.V.C. when the valve is used at high frequency because not only is the change in input capacity significant compared with the total circuit capacity, but the large change in input resistance will upset the damping controlling the bandwidth of the tuned circuit. At frequencies below 30 Mc/s the input impedance is sufficiently high to be neglected and the change in input capacity is small compared with the total capacity of the circuit.

4.32 Oscillator Stability: The three main factors affecting oscillator stability are the effects of temperature as the circuit warms up, the effect of mains supply voltage fluctuations, and the effect of the A.V.C. voltage.

The Curves 320·30 show the change of oscillator frequency with time as the circuit warms up after an initial 30 seconds have been allowed for the supply voltages to settle at their proper values. These curves, taken at signal frequencies of 18 and 90 Mc/s, are typical of the circuits shown on 320·57 and 320·58, and assume adequate ventilation and components of good quality which do not change their values through self heating. The exception to this last rule is at 90 Mc/s where a small amount of temperature compensation is provided by a negative temperature coefficient condenser across the oscillator tuned circuit.

Change of oscillator frequency with mains supply voltage variations is linear over all normal variations encountered, and is approximately 1 kc/s for 10% change in supply voltage. There is a further, but much smaller, frequency variation as the circuit settles down under the new conditions. This again applies to the typical circuits shown at the end of this report.

The effect of A.V.C. on the oscillator frequency at a frequency of 18 Mc/s is shown on 320·30 for the circuit shown on 320·57. This curve was taken with a well regulated HT supply, if the supply is poorly regulated the frequency shift may be increased.

4.33 Cross Modulation: When a receiver is tuned to a wanted signal and the signal grid of the mixer simultaneously receives another signal at some other frequency, a certain amount of interaction takes place between the two signals. If the unwanted signal is modulated, some of the modulation is impressed on the carrier of the wanted signal. If one assumes the two signals are modulated to the same depth the percentage of cross modulation is the ratio, expressed as a percentage, of the unwanted modulation appearing on the wanted signal to the wanted modulation. It is the custom to express the result as the level of interfering signal required to produce 1% cross modulation, and to modulate to a depth of 30% at 400 c/s. The level of the wanted signal does not affect the answer provided it is small enough not to exceed the linear range of the valve characteristic. For test purposes a level of 100 mV was used.

The curve on 320·33 shows for the 12AH8 the level of interfering signal for 1% cross modulation plotted against conversion conductance. For a given level of signal the cross modulation increases as the A.V.C. voltage is raised because the curvature of the characteristics increases. At low levels of conversion conductance where the A.V.C. voltage is very high the signals are wholly around the bend of the curve and the cross modulation decreases.

All valves are, to some extent, liable to produce cross-modulation due to non-linearity of their characteristics. Especially is this so when A.V.C. is applied, unless, by careful design, a smooth variable-μ characteristic is obtained. In the 12AH8 particular attention has been paid to this problem of providing a smooth A.V.C. characteristic without, at the same time, making the cut-off so remote as to require an excessive control voltage.

4.4 Typical Circuit Applications: Circuits are attached showing typical arrangements of a broadcast receiver for long, medium and short wave bands, and for the frequency changer of a V.H.F. receiver for 88 to 108 Mc/s. Data are given for aerial and oscillator coils for these circuits and curves are provided showing the variations in gain and oscillator grid current over each tuning range.

4.41 Long and Medium Waves: The circuit 320·57 shows an aerial and oscillator circuit of a 12AH8 frequency changer for normal broadcast reception. The coil data are given on pages 3 and 2 of 320·59. The gain figures and oscillator grid currents are shown on 320·27 and 320·26. When the HT voltage is 100 volts the screen and oscillator anode voltage dropping resistors are omitted, the connections being taken directly to the HT rail. The gain figures at signal frequency do not include the step-up in the aerial coil, being taken with a low impedance signal source connected directly to the signal grid.

4.42 Short Waves: The same circuit 320·57 is used for short wave operation. Coil data and gain figures are given for two wave bands. The normal short wave band found on receivers employing only one short wave band is 6 to 18 Mc/s. The coil data for this band is given on Sheet 1 of 320·59, and the gain and grid current curves are on 320·25. The gain figures do not include the step-up in the aerial coil.

Coil data for a further short wave band covering 18 to 30 Mc/s are given on Sheet 4 of 320·59. The gain and grid current figures are on 320·29.

On the short wave bands, when the oscillator must cover a wide frequency range, large variations in oscillator grid current are encountered as the tuning condenser is tuned from maximum to minimum. These variations can be reduced by including some series stabilising resistance in the feed-back circuit as shown on 320·57, where a 220 ohm resistor is connected in series with the oscillator anode on the short wave band. The optimum value of this resistor may, in practice, be different due to differences in circuit layout and coil construction, and account must be taken of its presence when the oscillator coil is designed so that more feedback may be provided in compensation.

4.43 V.H.F. Performance: A circuit is shown on 320·58 of the 12AH8 used as the frequency changer for a receiver to cover the international V.H.F. broadcast band of 88 to 108 Mc/s. For a cheaply priced receiver this valve could be used without a preceeding RF amplifier. Its equivalent noise resistance of 100 kΩ then sets a limit to the sensitivity of the receiver, as the noise voltage produced by the valve in a 200 kc/s bandwidth is approximately 18 μ volts. For local station FM reception this noise level is sufficiently below the threshold to be ignored.

The gain obtainable, including the aerial circuit step-up, is 16 times at mid band position, the extremes of the band yielding 15·8 and 18 times. The IF gain at 10·7 Mc/s is 11 times when the oscillator grid current is 200 μA. The IF bandwidth for these measurements was 200 kc/s which is that normally employed for FM of $\pm$75 kc/s deviation.

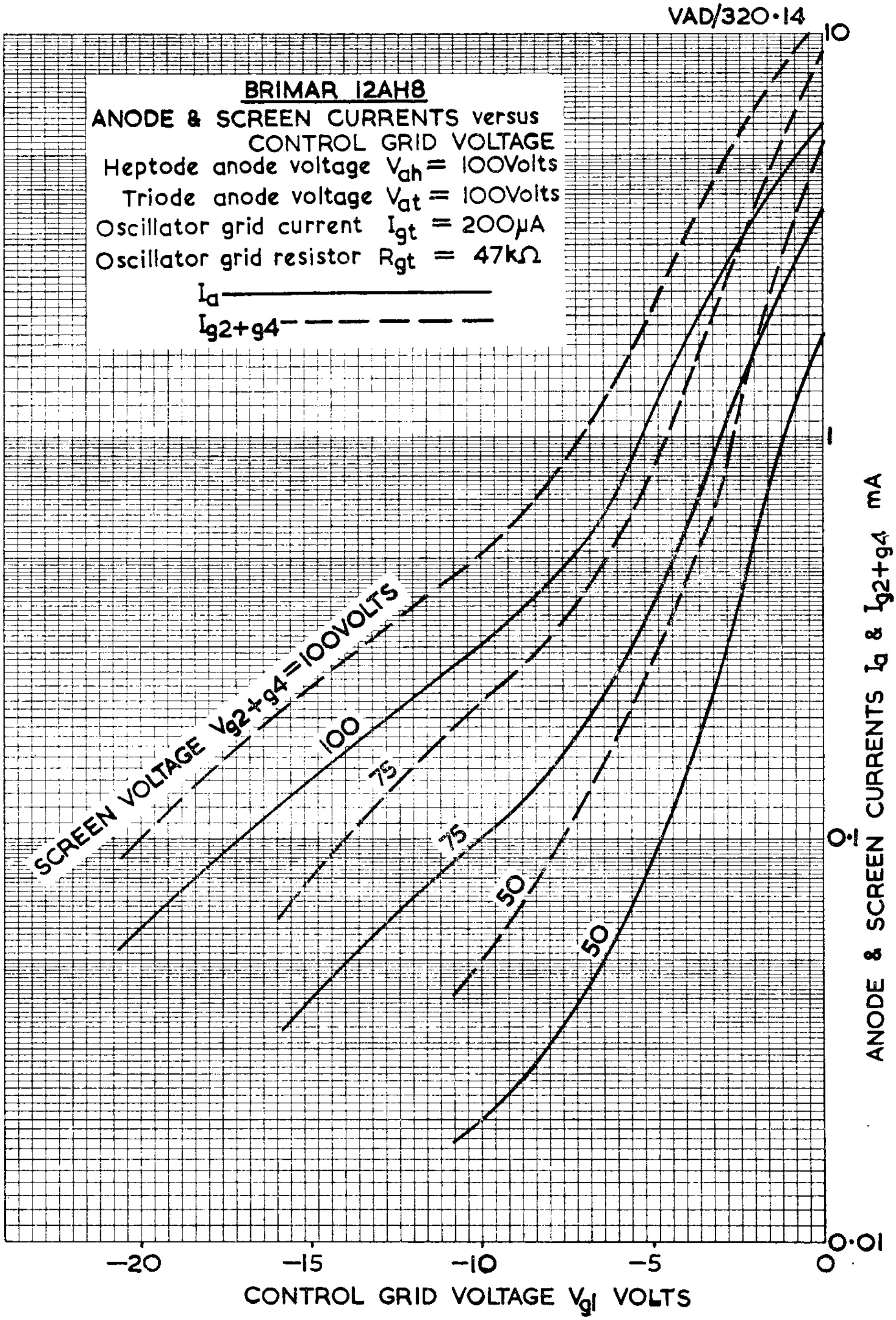
The coil details are as follows. Both coils are wound with 18 SWG tinned copper wire. The aerial coil consists of 2 turns, 1/2 in. internal diameter, 3/8 in. long. The tappings are, aerial 1/2 turn from earthy end, signal grid 1-3/4 turns from earthy end. The oscillator coil primary is wound on a 1/4 in. diameter form and has 3 turns. The coupling winding is 2-1/2 turns of insulated wire wound over the primary with a few layers of insulation such as "Alkothene" film in between.

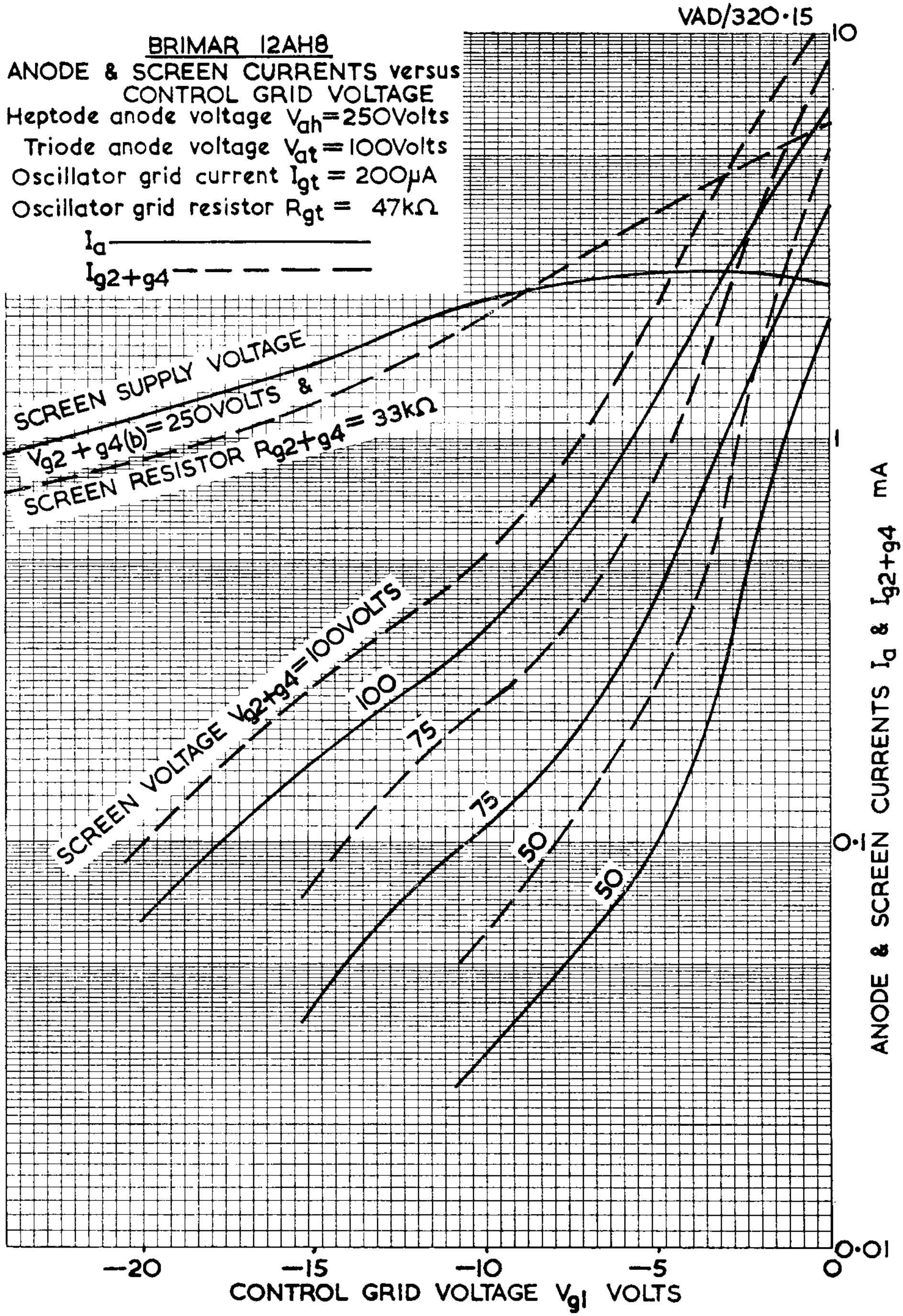
The oscillator frequency is set lower than the signal frequency by the difference of the IF, as this simplifies the requirements for frequency stability. To compensate for the change in capacity across the oscillator coil as the circuit warms up in the cabinet a negative temperature coefficient condenser is shunted across the tuning condenser. The exact value of this condenser will depend on the tuning and trimming condensers, but normally something of the order of 5 pF with a negative temperature coefficient of 30 parts per million is required. On 320·30 is shown the oscillator frequency drift due to the valve warming up. The circuit here was adequately cooled so that the majority of the frequency shift was due to the valve. No negative temperature coefficient condenser was used for this test. Normally this condenser is connected close to the valve holder so that it warms up at about the same rate as the valve. In practice the frequency drift during warm up can thus be held to within 20 kc/s.

The purpose of the choke in the live filament lead is to reduce the possibility of regeneration at IF when, as is often the case, a high gain IF amplifier follows the mixer.

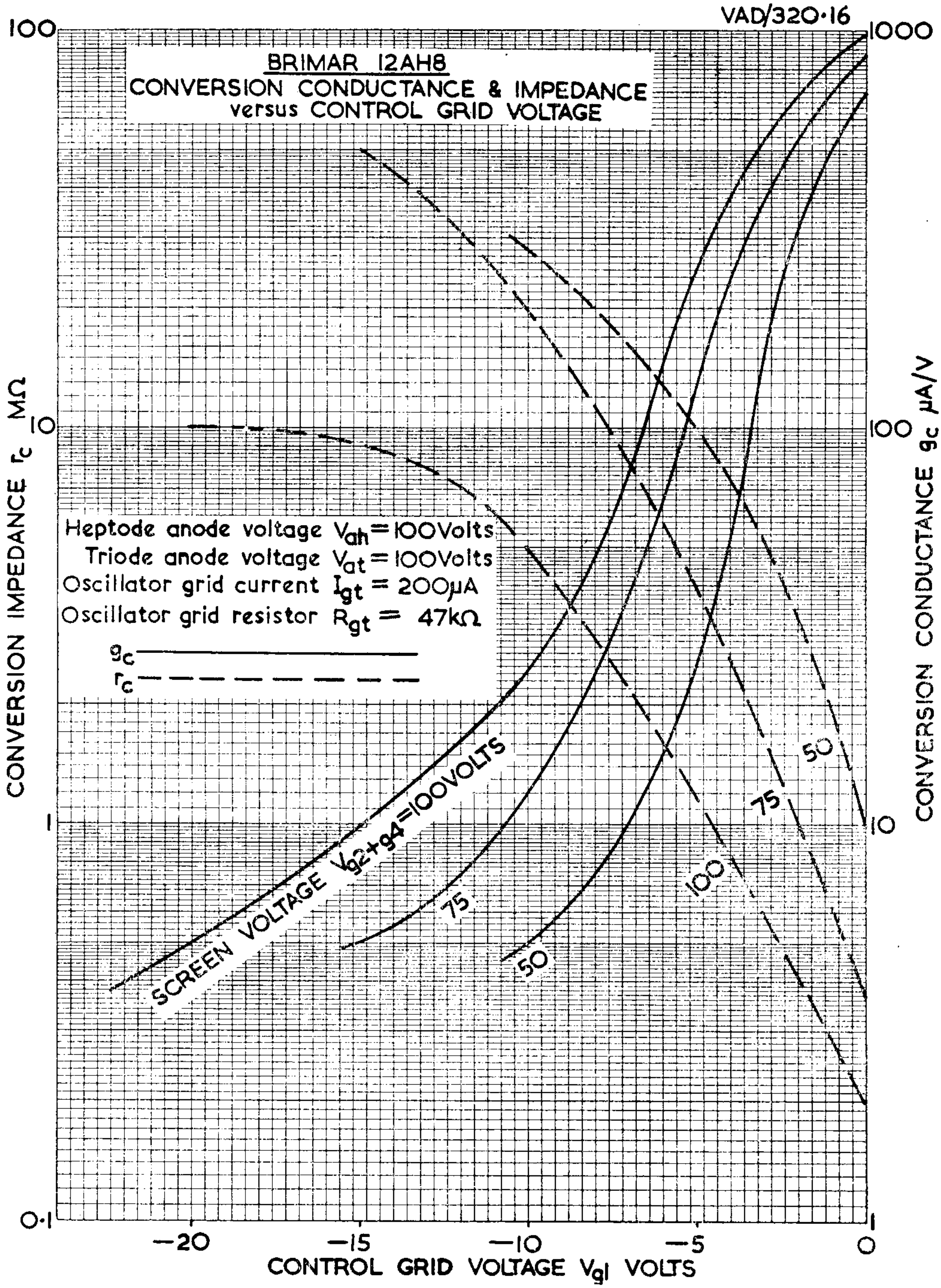
5.0 Other Applications: Triode Heptode frequency changer valves are not generally used for other than their intended purpose, as their characteristics are so specialised as to make them of little use in other applications.

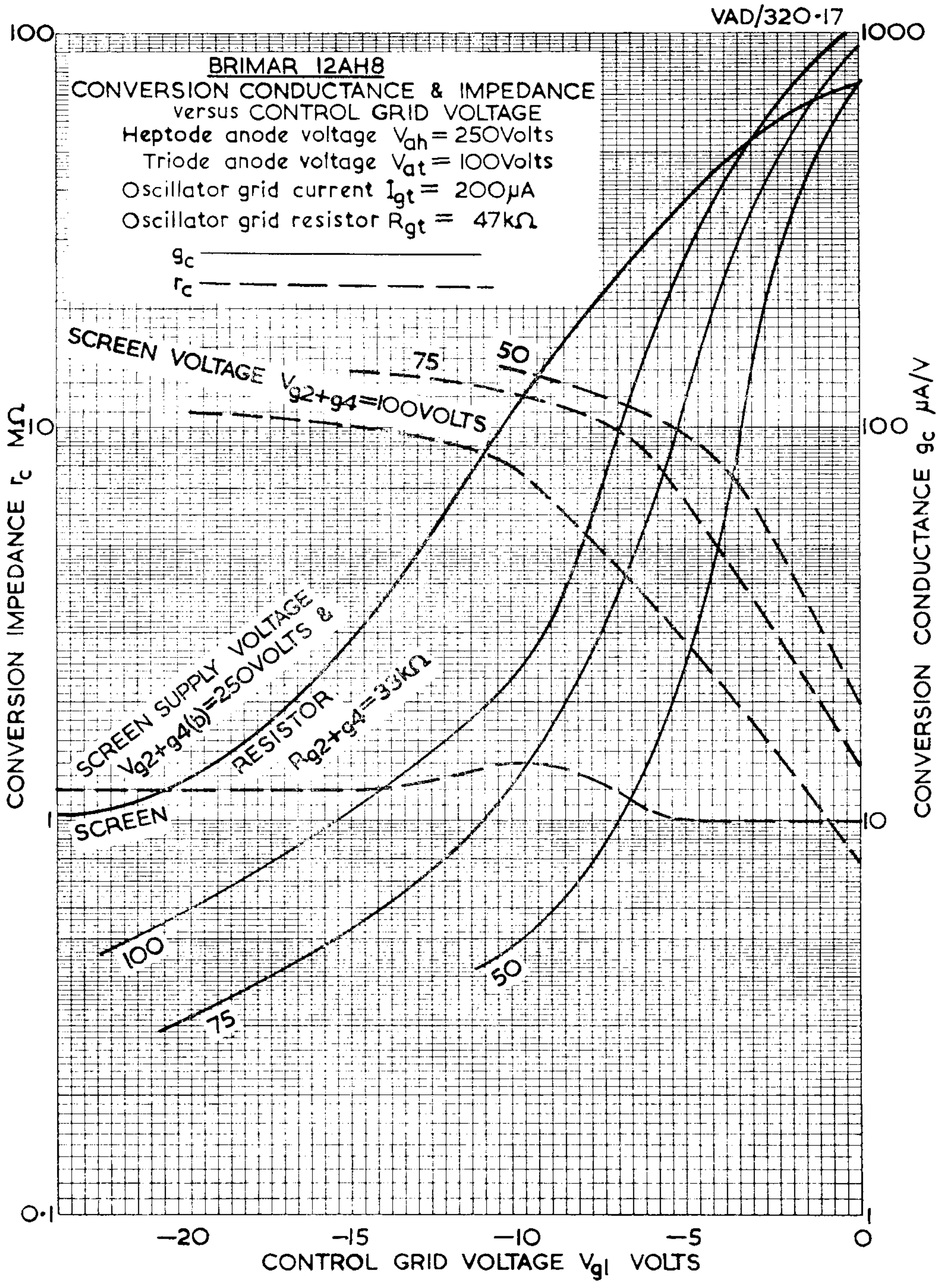
One field, however, where they often find use is in circuits where control is required individually and/or jointly from two separate signals without mutual interaction. Signals are supplied to the heptode grid 1 and grid 3, so the anode current is controlled by either signal and is also a function of their relative values and phase. Two sets of static characteristic curves are given for the 12AH8, Nos. 320·22 and 320·23, which show the control of both grid 1 and grid 3 over the anode and screen voltage. It should be noted that as the bias is increased on grid 3 the screen current rises, as most of the electrons are diverted to the grid 2 part of the screen which preceeds grid 3.

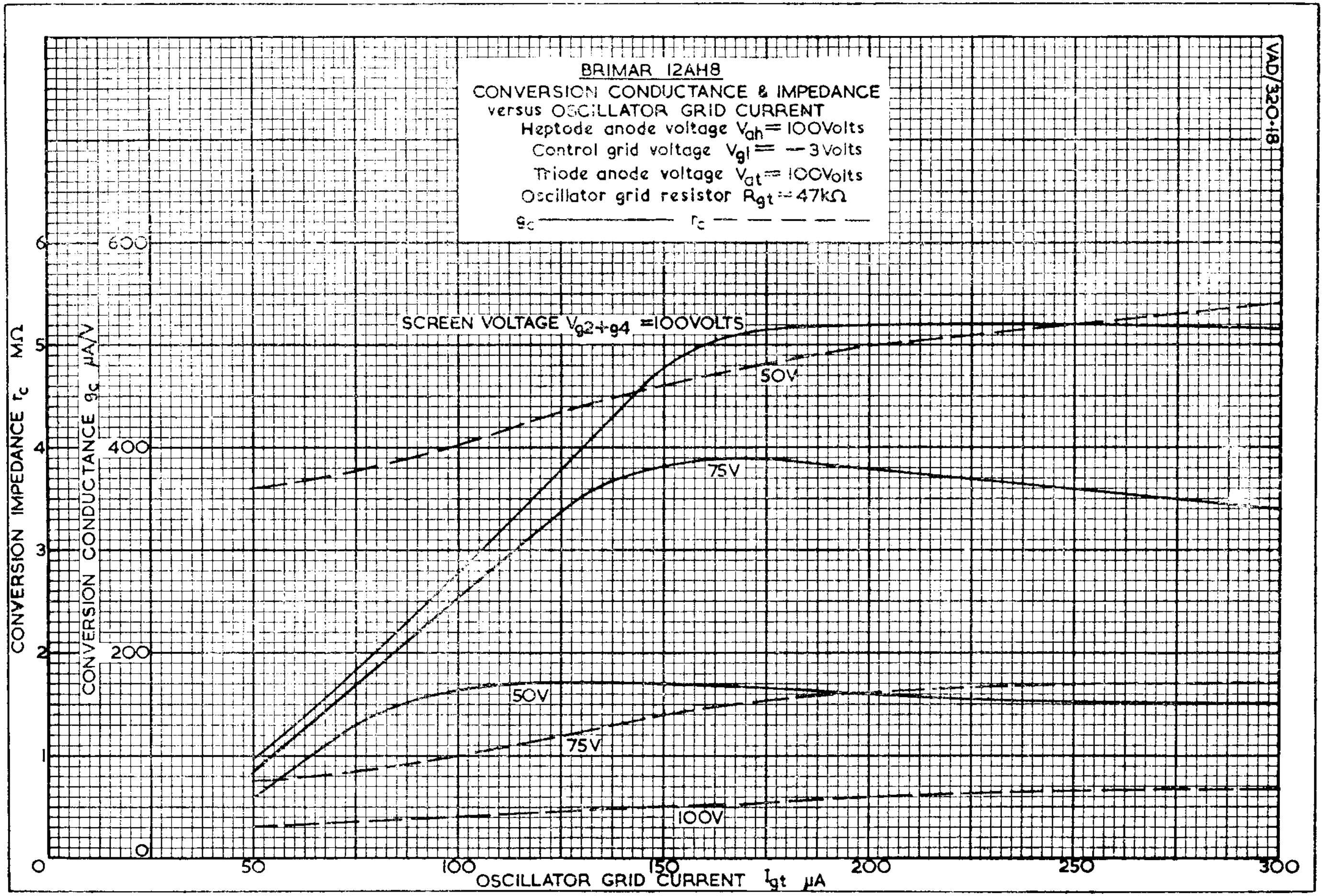

VAD/320·14
BRIMAR 12AH8
ANODE & SCREEN CURRENTS versus CONTROL GRID VOLTAGE
Heptode anode voltage Vah = 100Volts
Triode anode voltage Vat = 100Volts
Oscillator grid current Igt = 200μA
Oscillator grid resistor Rgt = 47kΩ
Ia
Ig2+g4
SCREEN VOLTAGE Vg2+g4=100VOLTS
100
75
75
50
50
10
1
0·1
0·01
−20
−15
−10
−5
0
CONTROL GRID VOLTAGE Vg1 VOLTS
ANODE & SCREEN CURRENTS Ia & Ig2+g4 mA

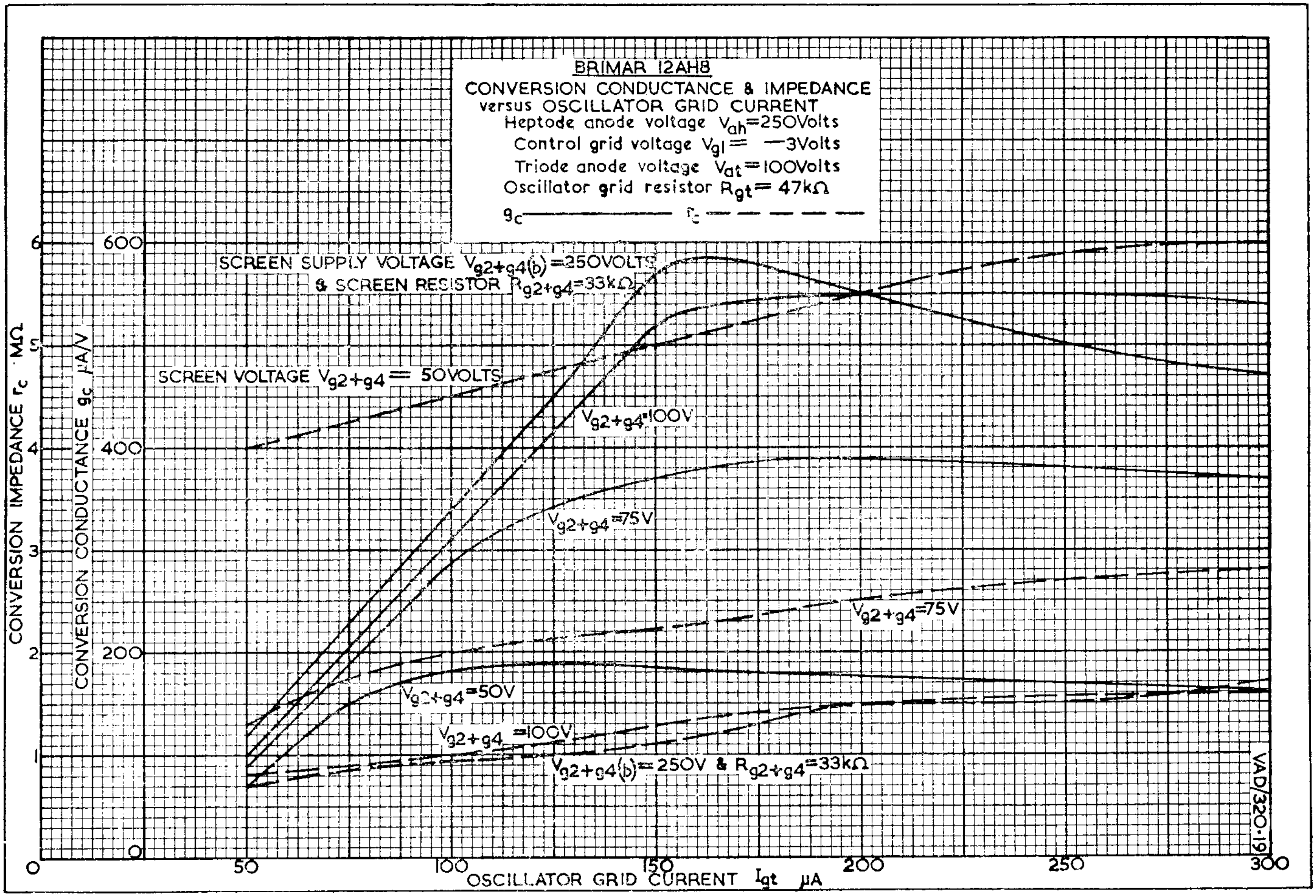


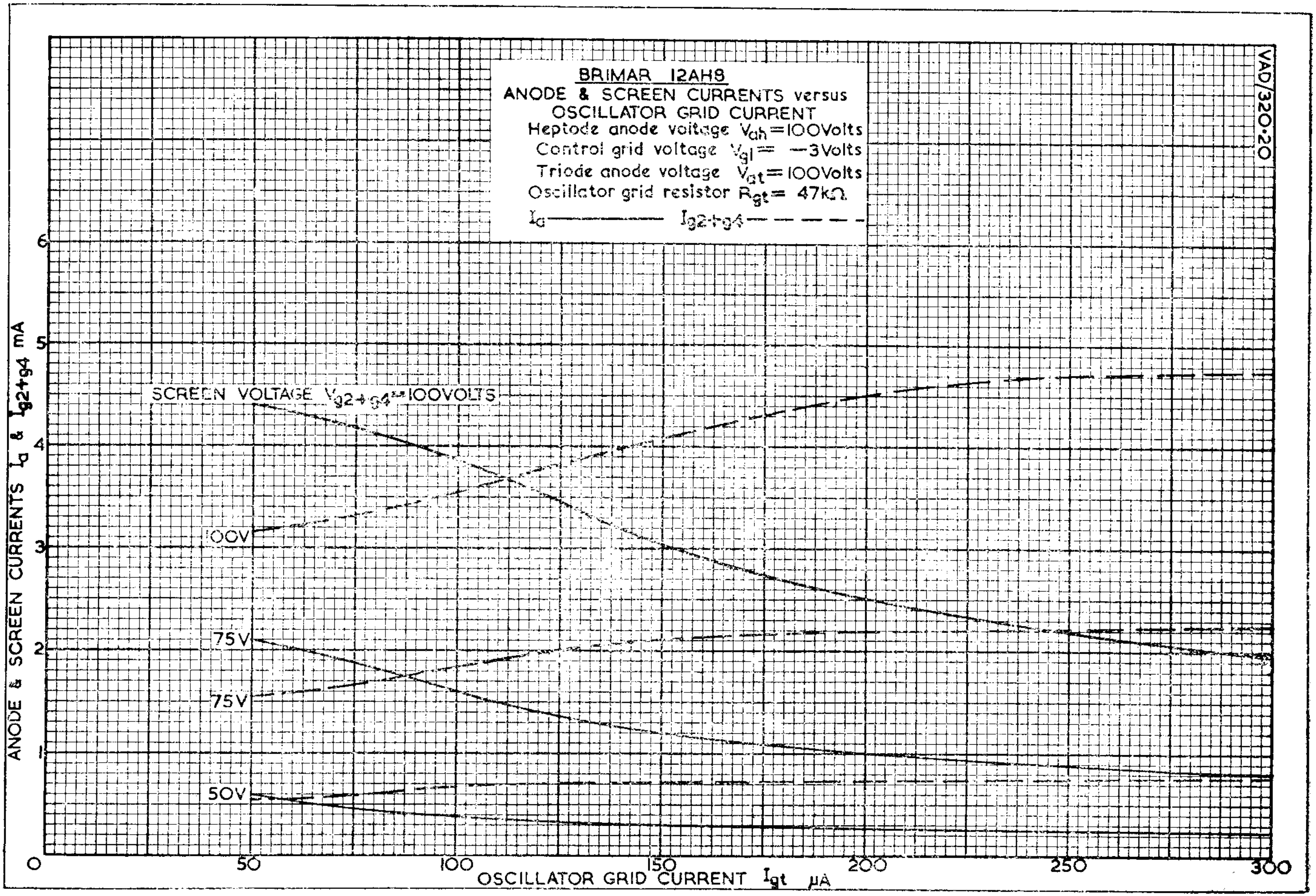
VAD/320·15
BRIMAR 12AH8
ANODE & SCREEN CURRENTS versus CONTROL GRID VOLTAGE
Heptode anode voltage Vah=250Volts
Triode anode voltage Vat=100Volts
Oscillator grid current Igt = 200μA
Oscillator grid resistor Rgt = 47kΩ
Ia
Ig2+g4
SCREEN SUPPLY VOLTAGE
Vg2 + g4(b)=250VOLTS &
SCREEN RESISTOR Rg2+g4= 33kΩ
SCREEN VOLTAGE Vg2+g4=100VOLTS
100
75
75
50
50
10
1
0·1
0·01
−20
−15
−10
−5
0
CONTROL GRID VOLTAGE Vg1 VOLTS
ANODE & SCREEN CURRENTS Ia & Ig2+g4 mA


VAD/320·16
BRIMAR 12AH8
CONVERSION CONDUCTANCE & IMPEDANCE
versus CONTROL GRID VOLTAGE
Heptode anode voltage Vah = 100Volts
Triode anode voltage Vat = 100Volts
Oscillator grid current Igt = 200μA
Oscillator grid resistor Rgt = 47kΩ
gc
rc
SCREEN VOLTAGE Vg2+g4=100VOLTS
75
50
100
75
50
CONVERSION IMPEDANCE rc MΩ
CONVERSION CONDUCTANCE gc μA/V
CONTROL GRID VOLTAGE Vg1 VOLTS
100
10
1
0·1
1000
100
10
1
−20
−15
−10
−5
0

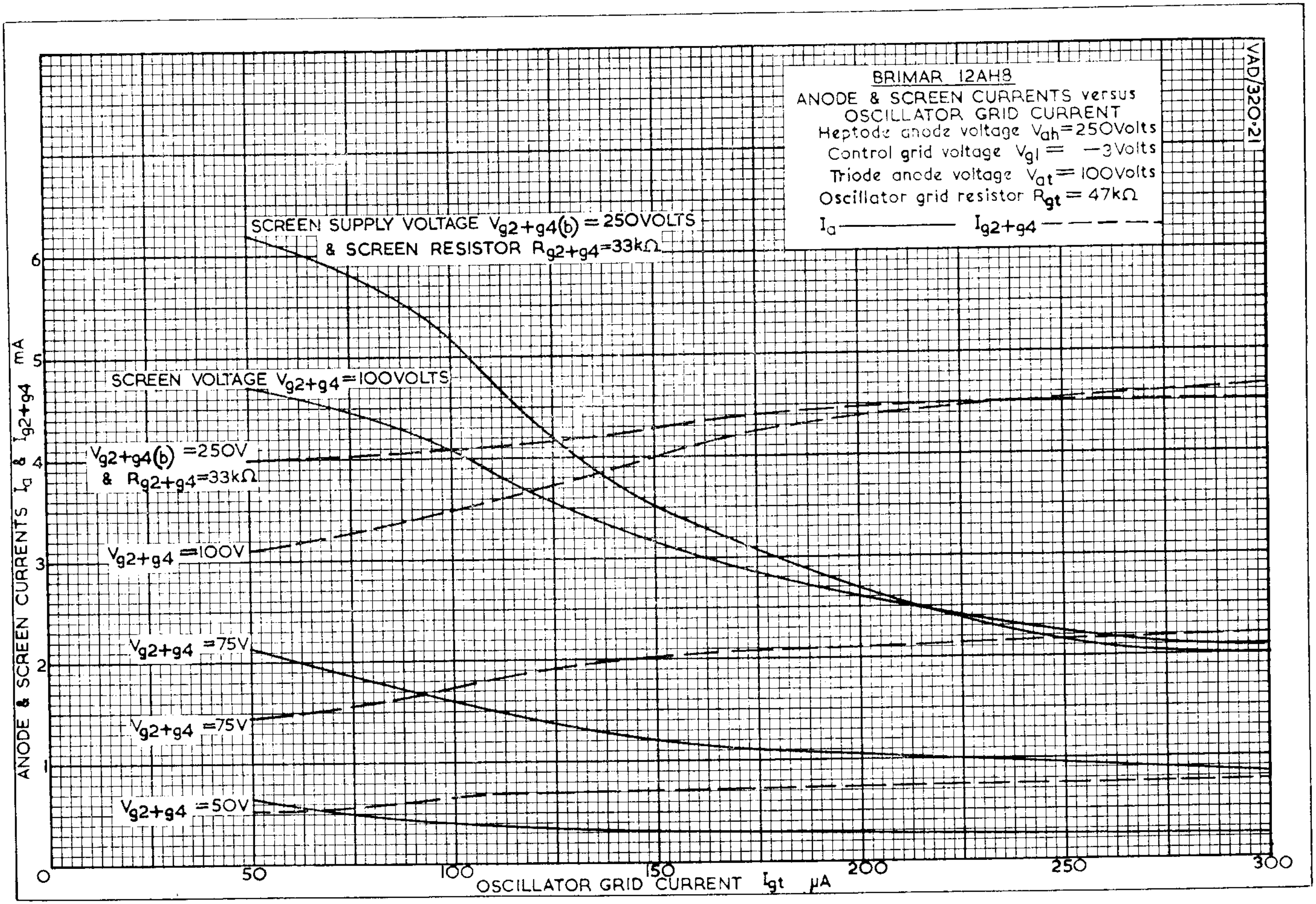

VAD/320-17
BRIMAR 12AH8
CONVERSION CONDUCTANCE & IMPEDANCE
versus CONTROL GRID VOLTAGE
Heptode anode voltage V_{ah} = 250Volts
Triode anode voltage V_{at} = 100Volts
Oscillator grid current I_{gt} = 200µA
Oscillator grid resistor R_{gt} = 47kΩ
g_c
r_c
SCREEN VOLTAGE V_{g2+g4}=100VOLTS
75
50
SCREEN SUPPLY VOLTAGE $V_{g2+g4(b)}$=250VOLTS &
SCREEN RESISTOR R_{g2+g4}=33kΩ
100
75
50
CONVERSION IMPEDANCE r_c MΩ
CONVERSION CONDUCTANCE g_c µA/V
CONTROL GRID VOLTAGE V_{g1} VOLTS
100
10
1
0·1
1000
100
10
1
−20
−15
−10
−5
0


VAD/320-18
BRIMAR 12AH8
CONVERSION CONDUCTANCE & IMPEDANCE
versus OSCILLATOR GRID CURRENT
Heptode anode voltage V_{ah} = 100Volts
Control grid voltage V_{g1} = −3Volts
Triode anode voltage V_{at} = 100Volts
Oscillator grid resistor R_{gt} = 47kΩ
g_c ———— r_c — — — —
SCREEN VOLTAGE V_{g2+g4} =100VOLTS
50V
75V
50V
75V
100V
CONVERSION IMPEDANCE r_c MΩ
CONVERSION CONDUCTANCE g_c μA/V
OSCILLATOR GRID CURRENT I_{gt} μA
0
50
100
150
200
250
300
1
2
3
4
5
6
200
400
600

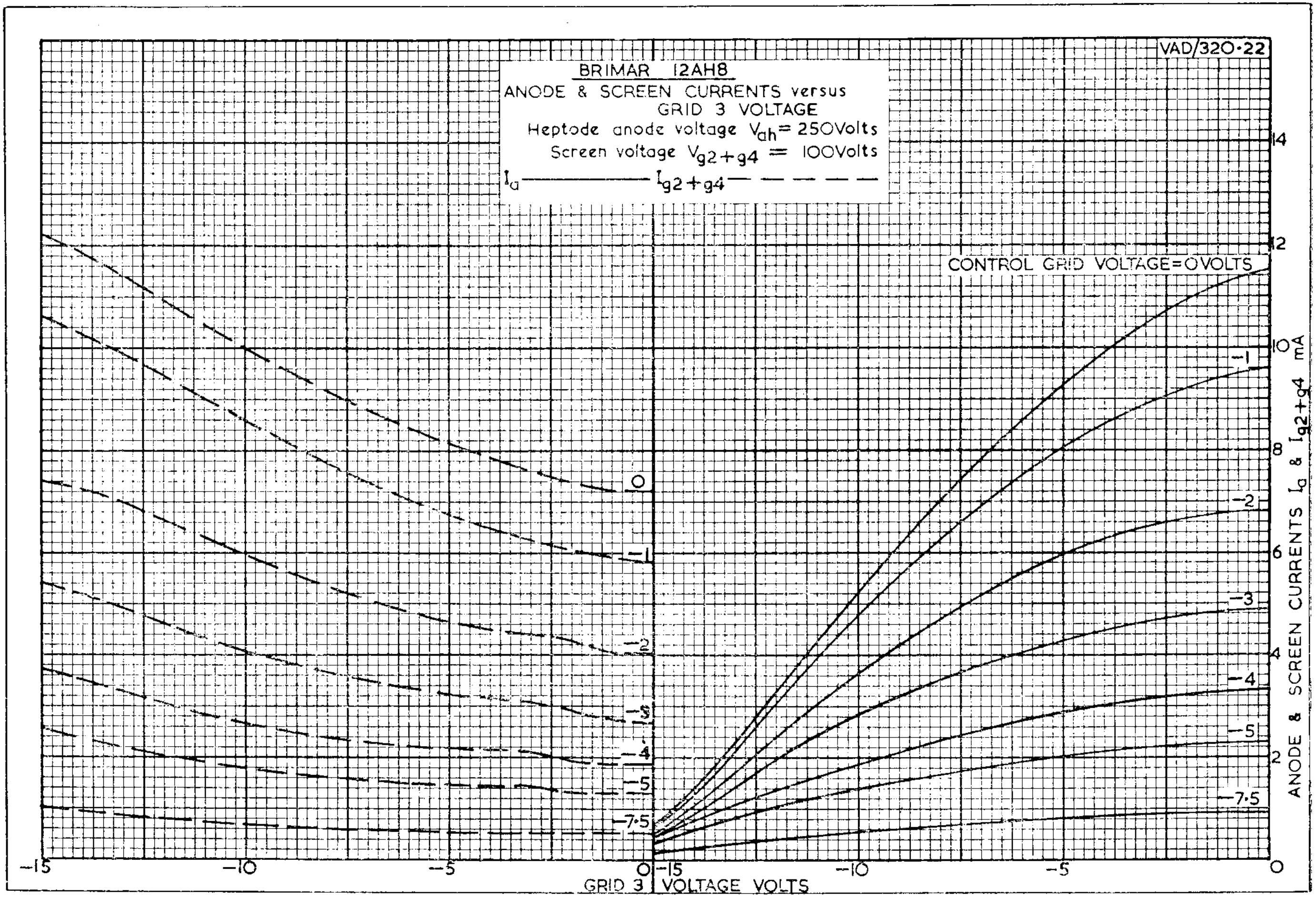

BRIMAR 12AH8
CONVERSION CONDUCTANCE & IMPEDANCE
versus OSCILLATOR GRID CURRENT
Heptode anode voltage V_{ah}=250Volts
Control grid voltage V_{g1}= −3Volts
Triode anode voltage V_{at}=100Volts
Oscillator grid resistor R_{gt}= 47kΩ
g_c ——— r_c – – –
SCREEN SUPPLY VOLTAGE $V_{g2+g4(b)}$=250VOLTS
& SCREEN RESISTOR R_{g2+g4}=33kΩ
SCREEN VOLTAGE V_{g2+g4}= 50VOLTS
V_{g2+g4}=100V
V_{g2+g4}=75V
V_{g2+g4}=75V
V_{g2+g4}=50V
V_{g2+g4} =100V
$V_{g2+g4(b)}$=250V & R_{g2+g4}=33kΩ
CONVERSION IMPEDANCE r_c MΩ
CONVERSION CONDUCTANCE g_c μA/V
OSCILLATOR GRID CURRENT I_{gt} μA
VAD/320-19
0
50
100
150
200
250
300
0
200
400
600
1
2
3
4
5
6

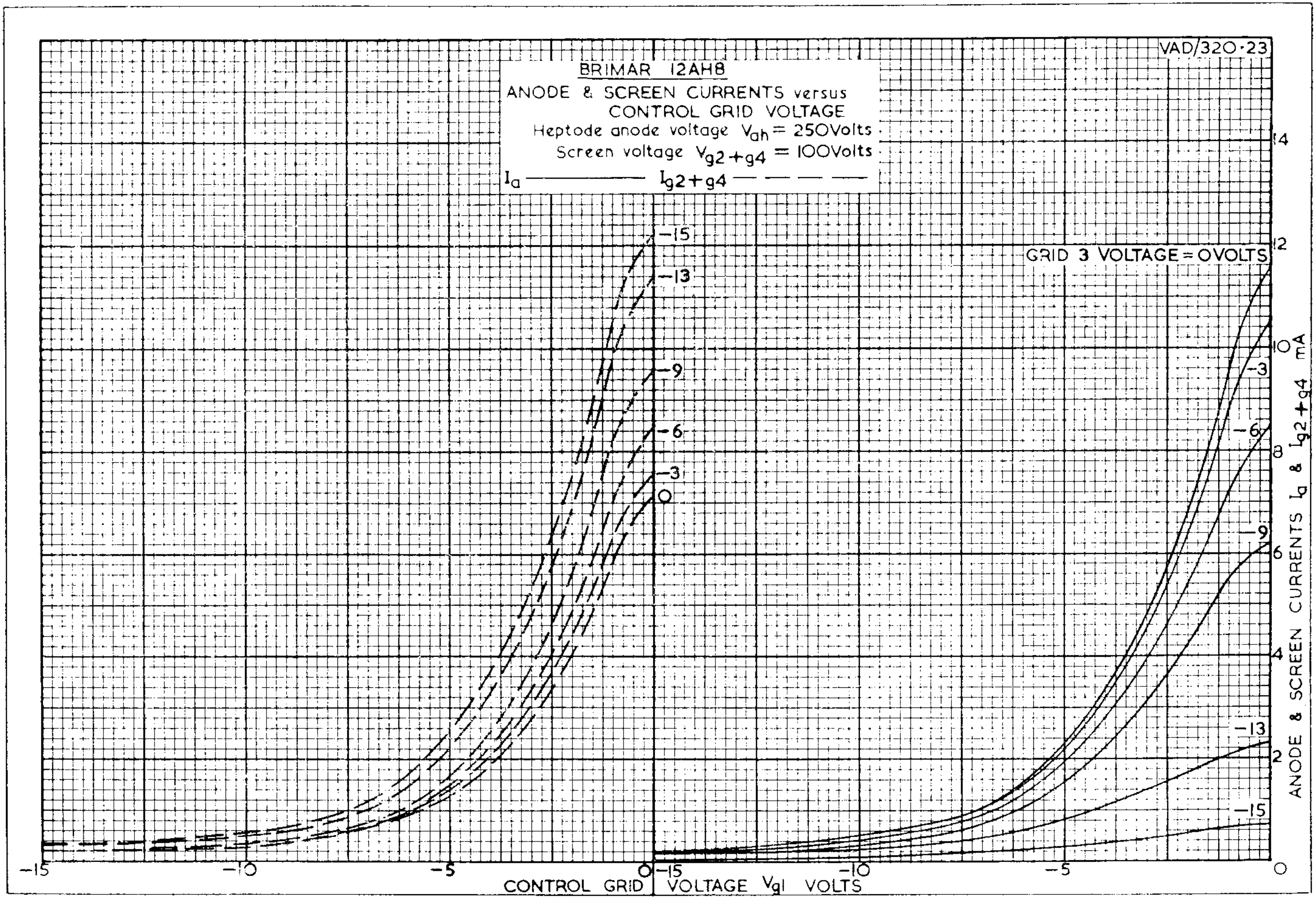


VAD/320·20
BRIMAR 12AH8
ANODE & SCREEN CURRENTS versus
OSCILLATOR GRID CURRENT
Heptode anode voltage V_{ah} = 100 Volts
Control grid voltage V_{g1} = −3 Volts
Triode anode voltage V_{at} = 100 Volts
Oscillator grid resistor R_{gt} = 47kΩ
I_a ——— I_{g2+g4} – – –
SCREEN VOLTAGE V_{g2+g4} = 100 VOLTS
100V
75V
75V
50V
ANODE & SCREEN CURRENTS I_a & I_{g2+g4} mA
OSCILLATOR GRID CURRENT I_{gt} μA
0
1
2
3
4
5
6
50
100
150
200
250
300

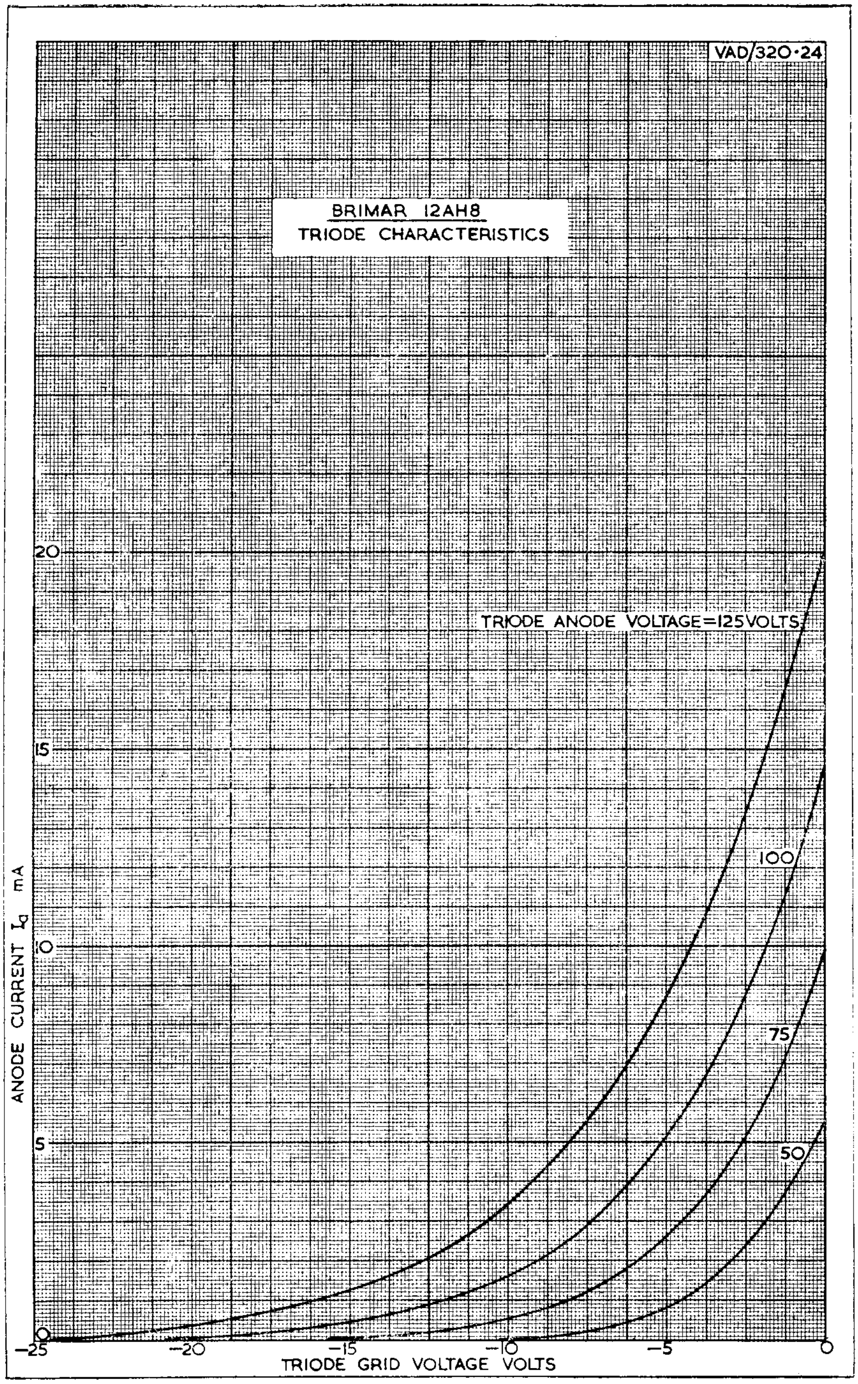


VAD/320·21
BRIMAR 12AH8
ANODE & SCREEN CURRENTS versus
OSCILLATOR GRID CURRENT
Heptode anode voltage V_{ah} = 250 Volts
Control grid voltage V_{g1} = −3 Volts
Triode anode voltage V_{at} = 100 Volts
Oscillator grid resistor R_{gt} = 47kΩ
I_a ———— I_{g2+g4} – – – –
SCREEN SUPPLY VOLTAGE $V_{g2+g4}(b)$ = 250 VOLTS
& SCREEN RESISTOR R_{g2+g4} = 33kΩ
SCREEN VOLTAGE V_{g2+g4} = 100 VOLTS
$V_{g2+g4}(b)$ = 250V
& R_{g2+g4} = 33kΩ
V_{g2+g4} = 100V
V_{g2+g4} = 75V
V_{g2+g4} = 75V
V_{g2+g4} = 50V
ANODE & SCREEN CURRENTS I_a & I_{g2+g4} mA
OSCILLATOR GRID CURRENT I_{gt} μA
0
50
100
150
200
250
300
1
2
3
4
5
6

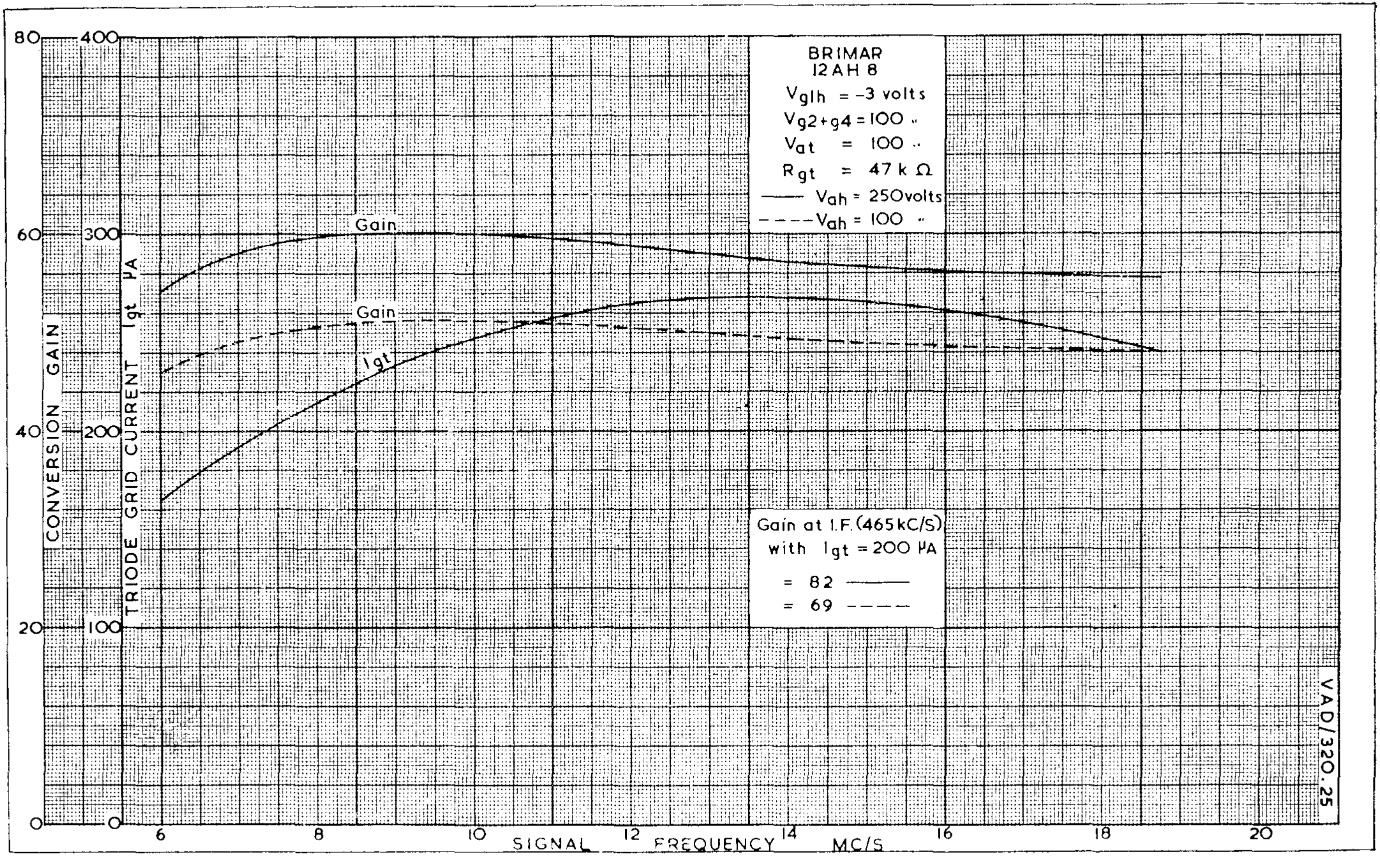

VAD/320·22
BRIMAR 12AH8
ANODE & SCREEN CURRENTS versus GRID 3 VOLTAGE
Heptode anode voltage Vah = 250Volts
Screen voltage Vg2+g4 = 100Volts
Ia ——— Ig2+g4 — — —
CONTROL GRID VOLTAGE=0VOLTS
0
-1
-2
-3
-4
-5
-7·5
ANODE & SCREEN CURRENTS Ia & Ig2+g4 mA
GRID 3 VOLTAGE VOLTS
-15
-10
-5
0
2
4
6
8
10
12
14

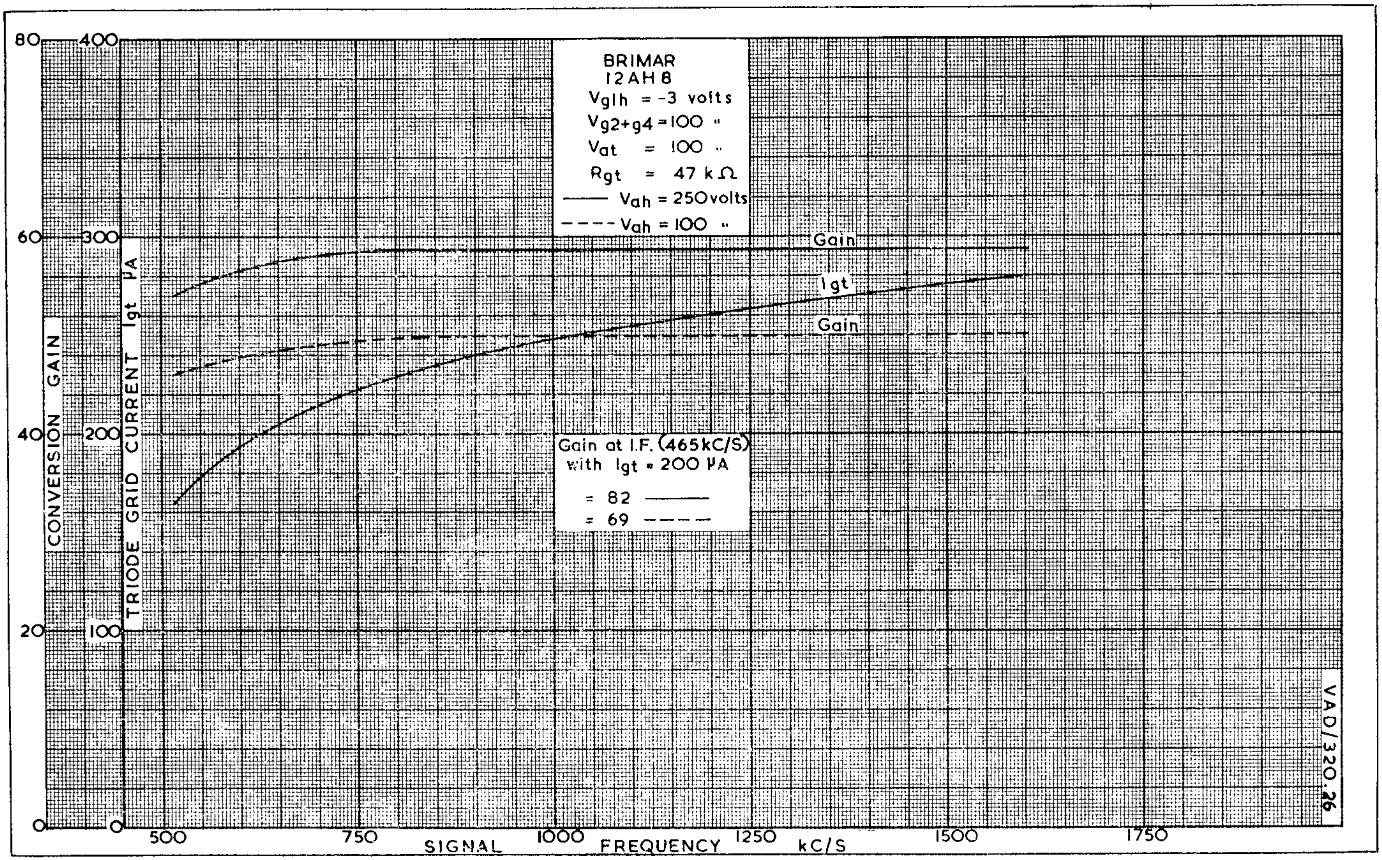


VAD/320·23
BRIMAR 12AH8
ANODE & SCREEN CURRENTS versus CONTROL GRID VOLTAGE
Heptode anode voltage V_{ah} = 250Volts
Screen voltage V_{g2+g4} = 100Volts
I_a ——— I_{g2+g4} — — —
GRID 3 VOLTAGE = 0VOLTS
−15
−13
−9
−6
−3
0
14
12
10
8
6
4
2
0
−15
−10
−5
0
ANODE & SCREEN CURRENTS I_a & I_{g2+g4} mA
CONTROL GRID VOLTAGE V_{g1} VOLTS

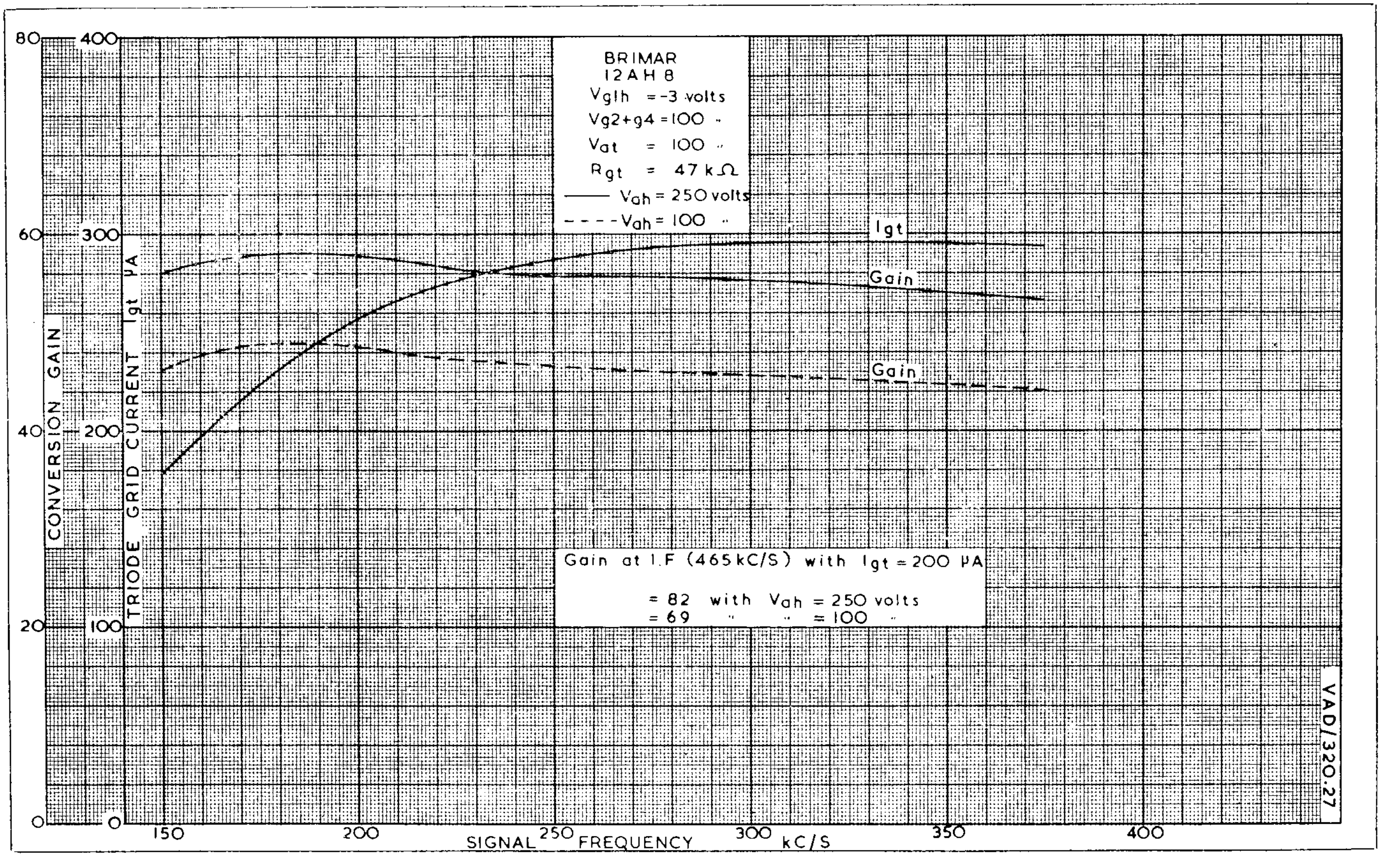


VAD/320·24
BRIMAR 12AH8
TRIODE CHARACTERISTICS
TRIODE ANODE VOLTAGE=125VOLTS
100
75
50
ANODE CURRENT Ia mA
20
15
10
5
0
−25
−20
−15
−10
−5
0
TRIODE GRID VOLTAGE VOLTS

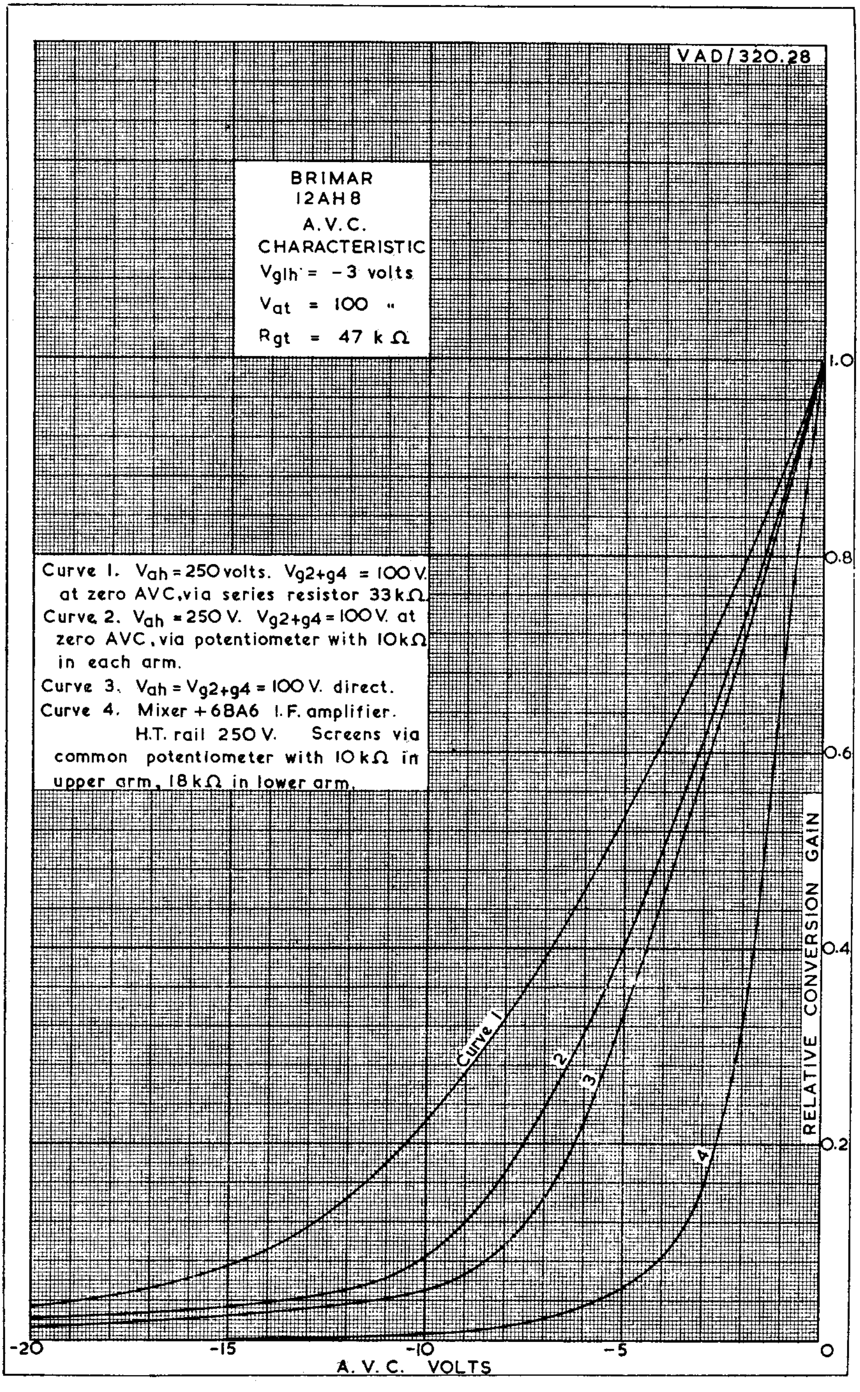

BRIMAR
12AH8
Vg1h = -3 volts
Vg2+g4 = 100 "
Vat = 100 "
Rgt = 47 k Ω
—— Vah = 250 volts
- - - - Vah = 100 "
Gain
Gain
Igt
Gain at I.F. (465 kC/S)
with Igt = 200 μA
= 82 ——
= 69 - - - -
CONVERSION GAIN
TRIODE GRID CURRENT Igt μA
SIGNAL FREQUENCY MC/S
0
20
40
60
80
100
200
300
400
6
8
10
12
14
16
18
20
VAD/320.25

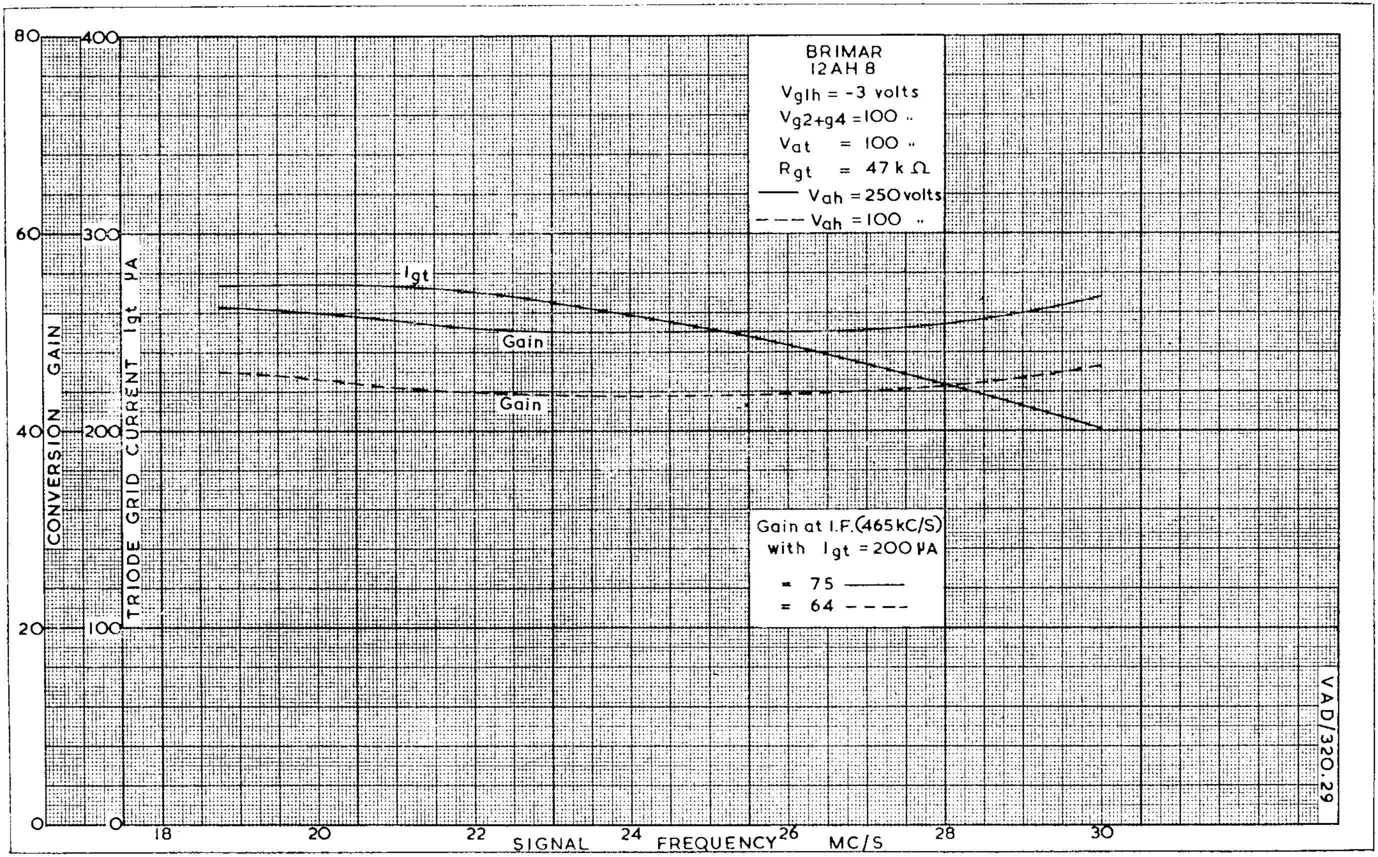


BRIMAR
12AH8
Vg1h = -3 volts
Vg2+g4 = 100 "
Vat = 100 "
Rgt = 47 kΩ
——— Vah = 250 volts
- - - - Vah = 100 "
Gain
Igt
Gain
Gain at I.F. (465kC/S)
with Igt = 200 μA
= 82 ———
= 69 - - - -
CONVERSION GAIN
TRIODE GRID CURRENT Igt μA
0
20
40
60
80
0
100
200
300
400
500
750
1000
1250
1500
1750
SIGNAL FREQUENCY kC/S
VAD/320.26

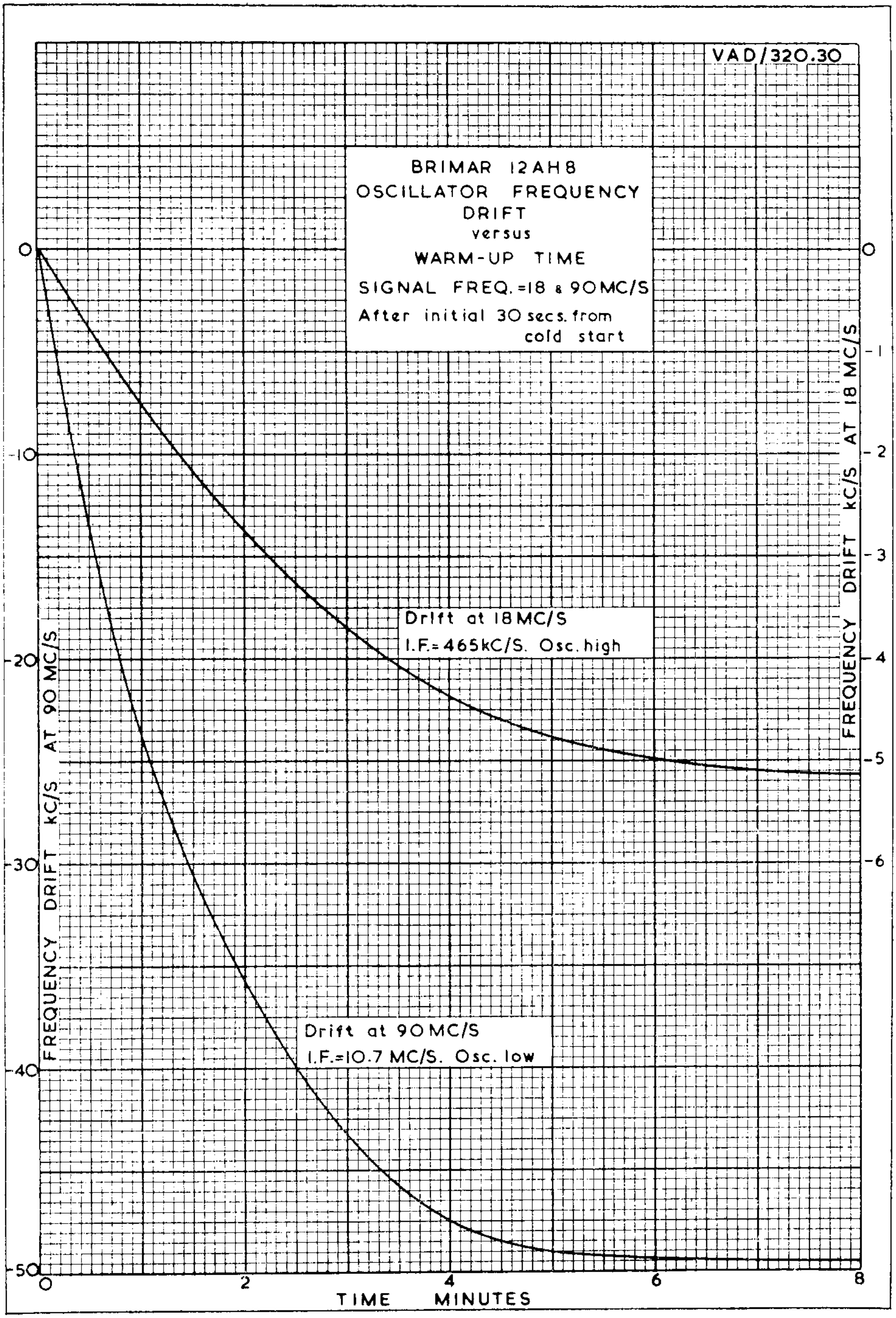


BRIMAR
12AH8
Vg1h = -3 volts
Vg2+g4 = 100 "
Vat = 100 "
Rgt = 47 kΩ
—— Vah = 250 volts
- - - - Vah = 100 "
Igt
Gain
Gain
Gain at I.F (465 kC/S) with Igt = 200 μA
= 82 with Vah = 250 volts
= 69 " " = 100 "
CONVERSION GAIN
TRIODE GRID CURRENT Igt μA
80
60
40
20
0
400
300
200
100
0
150
200
250
300
350
400
SIGNAL FREQUENCY kC/S
VAD/320.27

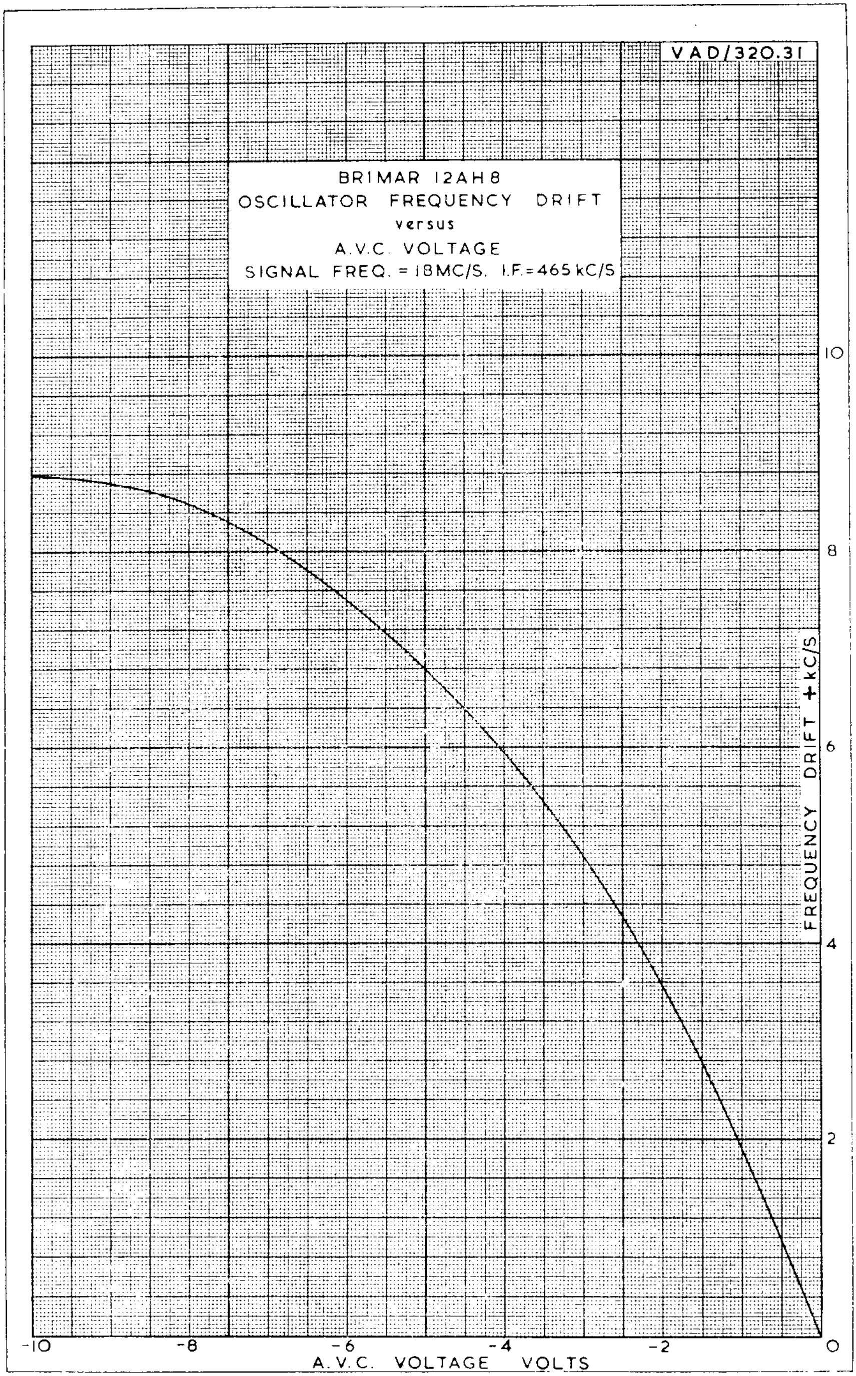

VAD/320.28
BRIMAR
12AH8
A.V.C.
CHARACTERISTIC
V_{g1h} = −3 volts
V_{at} = 100 "
R_{gt} = 47 kΩ
Curve 1. V_{ah} = 250 volts. V_{g2+g4} = 100 V. at zero AVC, via series resistor 33 kΩ.
Curve 2. V_{ah} = 250 V. V_{g2+g4} = 100 V. at zero AVC, via potentiometer with 10 kΩ in each arm.
Curve 3. V_{ah} = V_{g2+g4} = 100 V. direct.
Curve 4. Mixer + 6BA6 I.F. amplifier. H.T. rail 250 V. Screens via common potentiometer with 10 kΩ in upper arm, 18 kΩ in lower arm.
Curve 1
2
3
4
RELATIVE CONVERSION GAIN
1.0
0.8
0.6
0.4
0.2
0
-20
-15
-10
-5
A. V. C. VOLTS

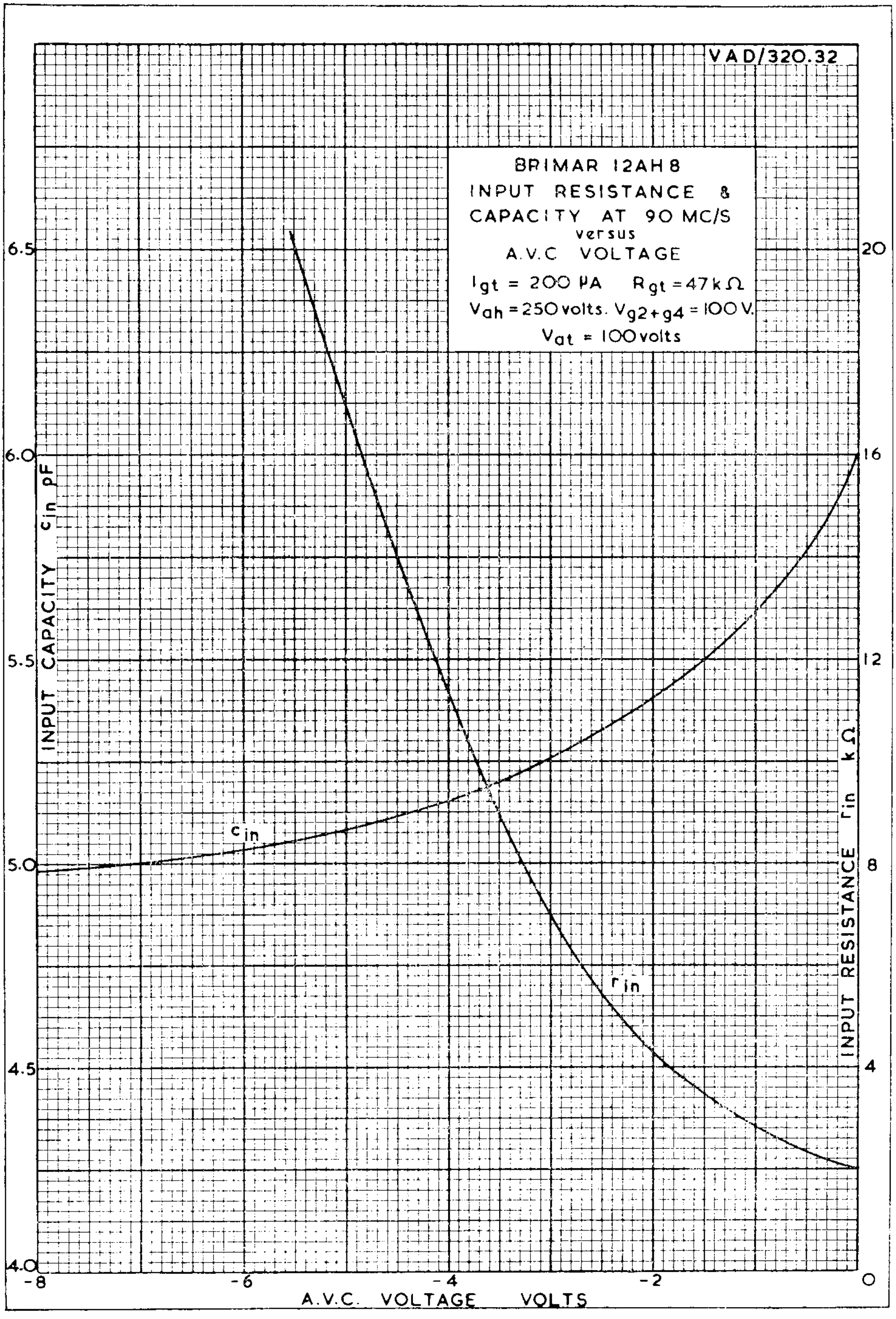


BRIMAR
12AH8
V_{g1h} = -3 volts
V_{g2+g4} = 100 "
V_{at} = 100 "
R_{gt} = 47 k Ω
—— V_{ah} = 250 volts
- - - V_{ah} = 100 "
I_{gt}
Gain
Gain
Gain at I.F. (465 kC/S) with I_{gt} = 200 μA
= 75 ——
= 64 - - - -
CONVERSION GAIN
TRIODE GRID CURRENT I_{gt} μA
SIGNAL FREQUENCY MC/S
0
20
40
60
80
0
100
200
300
400
18
20
22
24
26
28
30
VAD/320.29

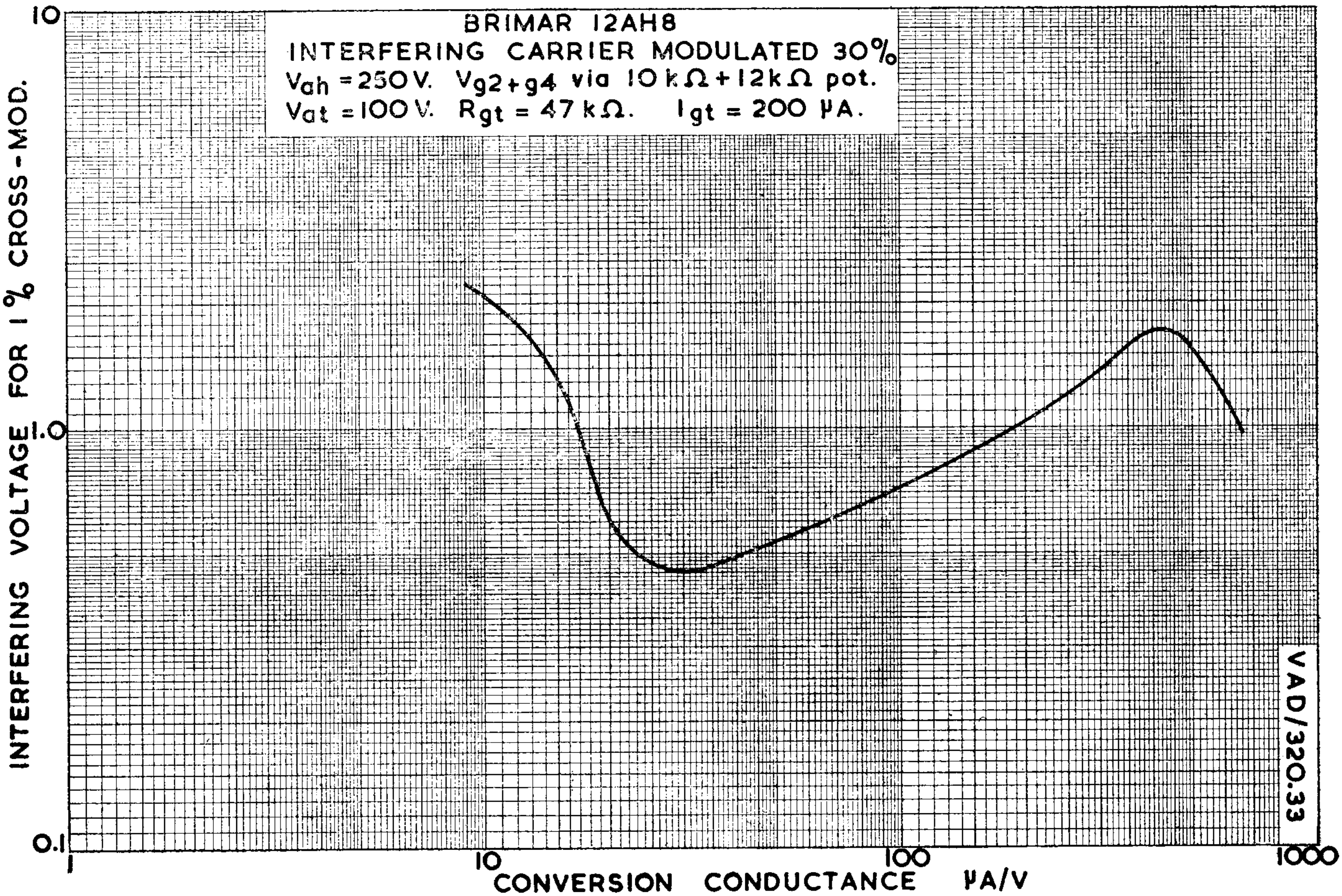


VAD/320.30
BRIMAR 12AH8
OSCILLATOR FREQUENCY
DRIFT
versus
WARM-UP TIME
SIGNAL FREQ.=18 & 90MC/S
After initial 30 secs. from
cold start
Drift at 18MC/S
I.F.=465kC/S. Osc. high
Drift at 90MC/S
I.F.=10.7MC/S. Osc. low
FREQUENCY DRIFT kC/S AT 90 MC/S
FREQUENCY DRIFT kC/S AT 18 MC/S
TIME MINUTES
0
-10
-20
-30
-40
-50
-1
-2
-3
-4
-5
-6
2
4
6
8


VAD/320.31
BRIMAR 12AH8
OSCILLATOR FREQUENCY DRIFT
versus
A.V.C. VOLTAGE
SIGNAL FREQ. = 18MC/S. I.F.=465 kC/S
FREQUENCY DRIFT +kC/S
10
8
6
4
2
0
-10
-8
-6
-4
-2
A.V.C. VOLTAGE VOLTS

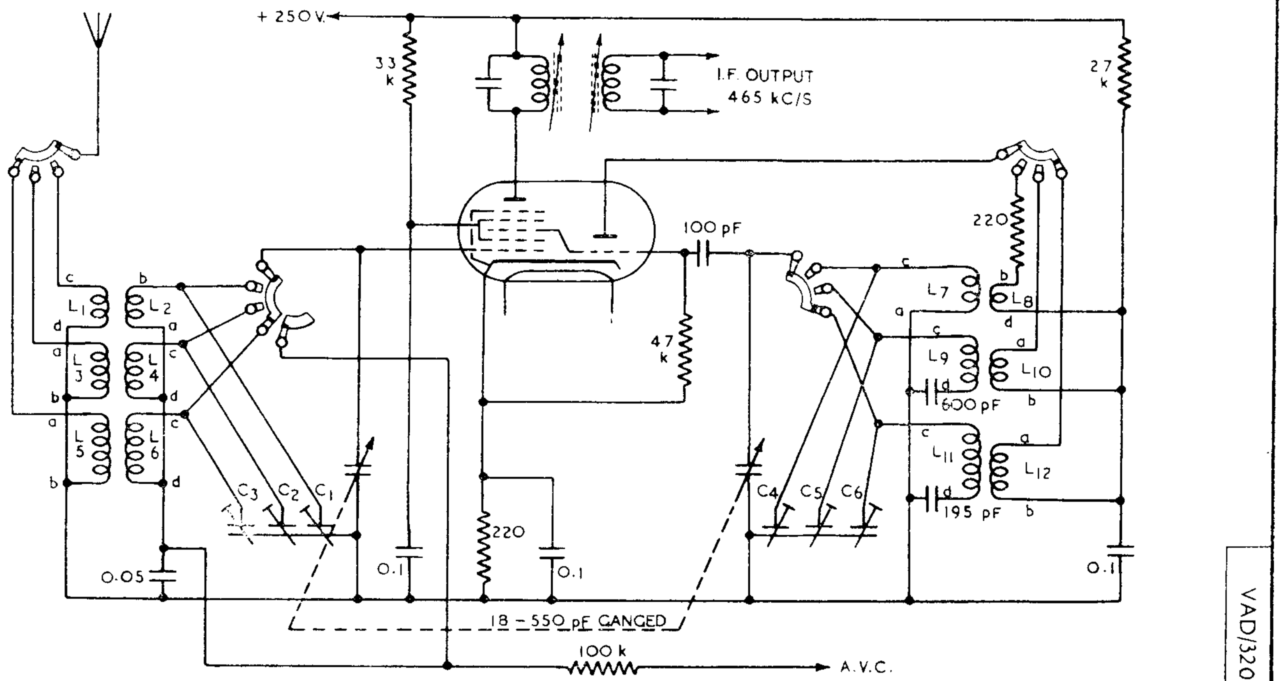


VAD/320.32
BRIMAR 12AH8
INPUT RESISTANCE &
CAPACITY AT 90 MC/S
versus
A.V.C VOLTAGE
I_{gt} = 200 μA R_{gt} = 47 kΩ
V_{ah} = 250 volts. V_{g2+g4} = 100 V.
V_{at} = 100 volts
INPUT CAPACITY c_{in} pF
INPUT RESISTANCE r_{in} kΩ
c_{in}
r_{in}
6.5
6.0
5.5
5.0
4.5
4.0
20
16
12
8
4
0
-8
-6
-4
-2
A.V.C. VOLTAGE VOLTS



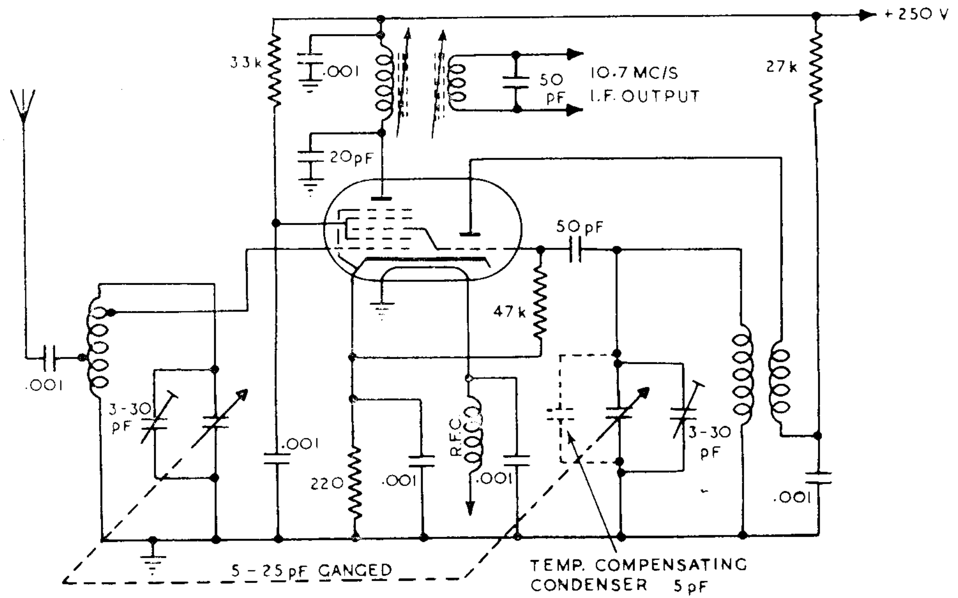
BRIMAR 12AH8
INTERFERING CARRIER MODULATED 30%
Vah = 250 V. Vg2+g4 via 10 kΩ + 12 kΩ pot.
Vat = 100 V. Rgt = 47 kΩ. Igt = 200 μA.
VAD/320.33
10
1.0
0.1
1
10
100
1000
INTERFERING VOLTAGE FOR 1% CROSS-MOD.
CONVERSION CONDUCTANCE μA/V

BRIMAR 12AH8 LONG MEDIUM & SHORT WAVE CONVERTER CIRCUIT



VAD/320.57

BRIMAR 12AH8 CONVERTER CIRCUIT FOR V.H.F. BAND
88 - 108 MC/S

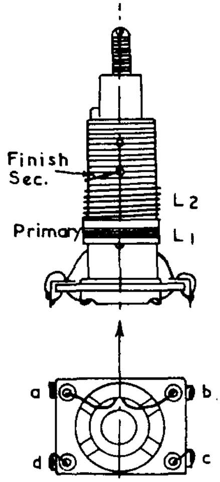


VAD/320.58

BRIMAR 12AH8

SHORT-WAVE COIL DATA

S.W. AERIAL



L.2 = 1·42 µH
Q at 10 Mc/s = 72

Former: 1/2″ outside diameter moulded bakelite, threaded 10 turns per cm.

Iron Dust Core: Neosid Z.11.B.

Secondary: 9 turns of 22 SWG En. Cu. wire wound in grooving, clockwise from start in the direction of arrow.

Start taken through hole in former to tag "a".

Finish taken through hole in former to tag "b".

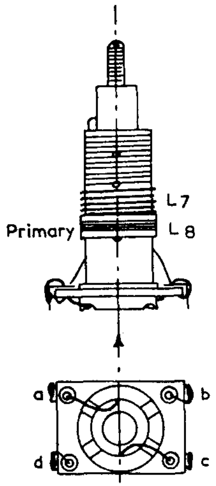
Primary: 4 turns of 38 SWG D.S.C. wire close wound on two layers of Bitumenised paper, 3/16″ wide, placed over the earthy end of the coil, clockwise from start in direction of arrow.

Start taken to tag "c".

Finish taken to tag "d".

Trimmer: C.1. 4—40 pF.

S.W. OSCILLATOR



L.7 = 1·24 µH
Q at 10 Mc/s = 70

Former: As above.

Iron Dust Core: As above.

Secondary: 8-1/2 turns of 22 SWG En. Cu. wire wound in grooving, clockwise from start in direction of arrow.

Start taken through hole in former to tag "a".

Finish taken through hole in former to tag "c".

Primary: 4 turns of 38 SWG D.S.C. wire close wound on two layers of Bitumenised paper, 3/16″ wide, placed over the earthy end of the coil, clockwise from start in the direction of arrow.

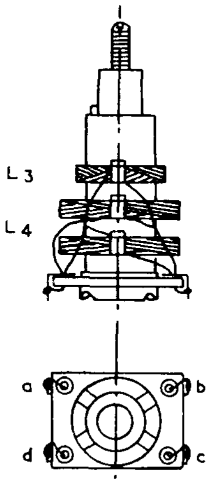
Start taken to tag "b".

Finish taken to tag "d".

Trimmer: C.4. 4—40 pF.

BRIMAR 12AH8

MEDIUM-WAVE COIL DATA



L.4. = 170 μH
Q at 1 Mc/s = 145

M.W. AERIAL

Former: 1/2″ outside diameter moulded bakelite.

Iron Dust Core: Neosid Z.11.B.

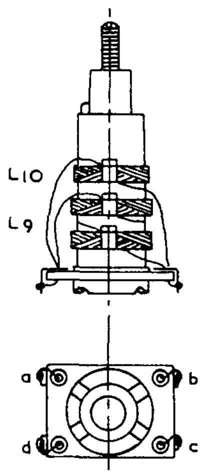
Secondary: L.4. 57 + 57 turns of 30/48 Litz. Single-wave wound, in two sections 1/8″ wide, spaced 1/8″.
Start taken to tag "c".
Finish taken to tag "d".

Gears: (Douglas) 50—32—34—50: 60—60.

Primary: L.3. 30 turns of 38 SWG D.S.C. wire. Double-wave wound, 1/8″ wide, spaced 1/8″ from L.4.
Start taken to tag "b".
Finish taken to tag "a".

Gears: 50—41—42—50: 40—80.

Trimmer: C.2. 4—40 pF.



L.9 = 89 μH
Q at 1 Mc/s = 58

M.W. OSCILLATOR

Former: As above.

Iron Dust Core: As Above.

Secondary: L.9. 38 + 38 turns of 38 SWG D.S.C. wire. Double-wave wound in two sections 1/8″ wide, spaced 1/8″.
Start taken to tag "c".
Finish taken to tag "d".

Gears: 50—41—42—50: 40—80.

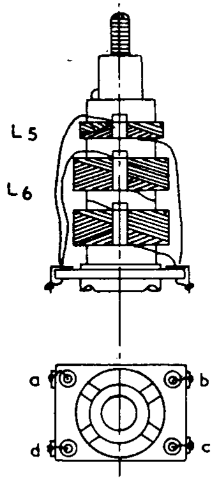
Primary: L.10. 28 turns of 38 SWG D.S.C. wire. Double-wave 1/8″ wide, spaced 1/8″ from L.9. Wound in same direction from start as L.9.
Start taken to tag "b".
Finish taken to tag "a".

Gears: As for L.9.

Trimmer: C.5. 4—40 pF.

BRIMAR 12AH8

LONG-WAVE COIL DATA



L.6 = 1·9 mH
Q at 200 kc/s = 62

L.W. AERIAL

Former: 1/2″ outside diameter moulded bakelite.

Iron Dust Core: Neosid Z.11.B.

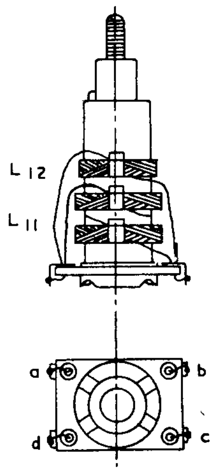
Secondary: L.6. 220 + 220 turns of 38 SWG D.S.C. wire, single-wave wound in two sections, 1/4″ wide, spaced 1/8″.
Start taken to tag "c".
Finish taken to tag "d".

Gears: (Douglas) 50—41—42—50: 60—60.

Primary: L.5. 100 turns of 38 SWG D.S.C. wire, double-wave wound, 1/8″ wide, spaced 1/8″ from L.6.
Start taken to tag "b".
Finish taken to tag "a".

Gears: 50—41—42—50: 40—80.

Trimmer: C.3. 40—80 pF.



L.11 = 440 μH
Q at 500 kc/s = 55

L.W. OSCILLATOR

Former: As above.

Iron Dust Core: As above.

Secondary: L.11. 97 + 97 turns of 38 SWG D.S.C. wire, double-wave wound in two sections, 1/8″ wide, spaced 1/8″.
Start taken to tag "c".
Finish taken to tag "d".

Gears: 50—41—42—50: 40—80.

Primary: L.12. 53 turns of 38 SWG D.S.C. wire, double-wave wound, 1/8″ wide, spaced 1/8″ from L.11. Wound in same direction from start as L.11.
Start taken to tag "b".
Finish taken to tag "a".

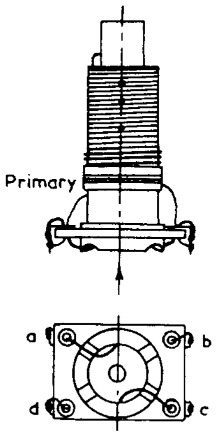
Gears: As for L.11.

Trimmer: C.6. 40—80 pF.

BRIMAR 12AH8

18—30 MC/S BAND COIL DATA

AERIAL



Former: 1/2″ outside diameter moulded bakelite, threaded 10 turns per cm.

Secondary: 5-1/2 turns of 22 SWG En. wire wound in grooving clockwise from start in direction of arrow.

Start taken through hole in former to tag "a".

Finish taken through hole in former to tag "c".

Primary: 3 turns of 38 SWG D.S.C. wire close wound on two layers of Bitumenised paper, 1/4″ wide, placed over the earthy end of secondary, clockwise from start in direction of arrow.

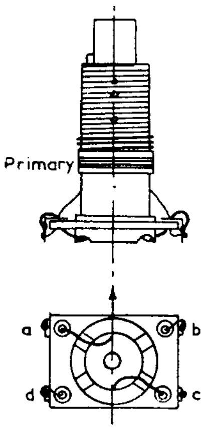
Start taken to tag "b".

Finish taken to tag "d".

Trimmer: 4—40 pF.

Secondary inductance = 0·56 μH

OSCILLATOR



Former: As above.

Secondary: As for Aerial.

Primary: 4 turns of 38 SWG D.S.C., otherwise same as Aerial.

Tag "a"—Earth: tag "b"—osc. anode via 150Ω: tag "c"—Tuning condenser: tag "d"—100 volt HT line.

Trimmer: 4—40 pF.

Tuning Condenser: 12—136 pF.

BRIMAR

RECEIVING VALVE

12AT7
ECC81

APPLICATION REPORT VAD/513.3

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

Issued April, 1950. Reprinted January, 1952.

1.0 INTRODUCTION: The Brimar type 12AT7 is an 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 or AC/DC equipment.

This report contains characteristics of the valve and details of its use as a normal amplifier, resistance capacity coupled amplifier, a frequency changer for ultra-short waves, oscillator, grounded grid amplifier and as a frequency multiplier.

2.0 DESCRIPTION: The valve comprises two triode units mounted side by side having separate heaters but common heater pin connections. The units are mounted in a standard T6½ bulb and based with a B.V.A. Standard base type B9A.

3.0 CHARACTERISTICS:

3.1 Cathode:

		Series	*Parallel*	
	Indirectly heated			
	Voltage	12·6	6·3	volts
	Nominal Current	0·15	0·3	ampere
	Max. Heater-Cathode potential (DC)		250 volts	

3.2 Dimensions:

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

3.3 Base: Noval Type B9A

3.4 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′.

3.5 Ratings (Design centre):

EACH TRIODE UNIT:

Max. Anode Voltage	300 volts
Max. Anode Dissipation	2·5 watts
Max. Cathode Current	20 mA
Max. Negative Control Grid Voltage	50 volts
Max. Average Grid Current	1 mA

3.6 Capacities (approx.):*

GROUNDED CATHODE OPERATION:

	Triode Unit′	*Triode Unit″*	
$c_{g,a}$	1·45	1·45	pF
$c_{g,kh}$	2·5	2·5	pF
$c_{a,kh}$	0·45	0·35	pF
$c_{h,k}$	2·5	2·5	pF
$c_{g',a''}$	0·20 pF		
$c_{g'',a'}$	0·20 pF		
$c_{a',a''}$	0·40 pF max.		
$c_{g',g''}$	0·005 pF max.		

* Measured with no external shield

GROUNDED GRID OPERATION:

$C_{a, k}$	0·15	0·15	pF
$C_{k, gh}$	5	5	pF
$C_{a, gh}$	1·6	1·5	pF

3.7 Characteristic Curves: Curves are attached to this report which show:

Anode current plotted against anode volts for various values of grid voltage (I_a/V_a) (Curve No. 313·13).

Anode current plotted against grid volts for various anode voltages (I_a/V_g) (Curve No. 313·14).

Mutual conductance, amplification factor and anode impedance plotted against anode current (g_m/I_a) (Curve No. 313·15).

4.0 Typical Operation:

4.1 Class A1 Amplifier:

Anode	100	180	250	volts
Grid	—1	—1	—2	volts
Amplification Factor (μ)	54	62	55	
Anode Impedance (r_a)	13500	9400	10000	ohms
Mutual Conductance	4·0	6·6	5·5	mA/V
Anode Current	3·7	11	10	mA
Grid Volts for I_a 10μA	—6	—8	—12	volts

4.2 Resistance Coupled Amplifier: The valve may be used as a resistance coupled amplifier, and 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. 313·16, is measured at an anode supply voltage $V_{a(b)}$ of 250 volts with three values of anode load resistance, viz.: 47,000, 100,000, 220,000 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, also 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 the graph.

If, for example, it is desired to use the valve at a supply voltage of 250 volts, an anode load of 100,000 ohms and a succeeding valve grid leak of 470,000 ohms, then, to determine the grid bias, an inspection of the graph indicates a relatively linear portion of the curve of anode current/grid volts over the range of —1·0 to —5·0 volts, the mid point being —3 volts. At this point the anode current is 1 mA, hence the cathode resistance should be 3,300 ohms. The peak input voltage is, say, 2 volts and the R.M.S. input 1·4 volts. Following the grid bias voltage upward it is evident that, with an anode load of 100,000 ohms, the amplification factor (μ) is 37 and the anode impedance is 33,000 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 100,000 ohms in parallel with 470,000 ohms or is 82,000 ohms. The stage gain is:

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

or, in the above case:

$$\frac{37 \times 82{,}000}{82{,}000 + 33{,}000} = 26{\cdot}5.$$

The peak input voltage above was 2 volts, hence the peak output voltage will be this figure multiplied by the stage gain or 53 volts or 37·5 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 —1·0 volts is 38 and at —5·0 volts is 18·6, hence the positive peaks of the signal output will be less than the negative and the distortion at this input will be 17%.

4.3 Frequency Changer:

4.31 The valve is designed to perform efficiently as a frequency changer in receivers for short or ultra-short waves. It has the advantages of a low noise factor and a high conversion gain, this is particularly so when high intermediate frequencies are used in order to achieve wide band width or good second channel ratio. It is not suitable for this application when the signal frequency is of the same order as the intermediate frequency, as on medium or long waves with an IF of 465 Kc/s.

4.32 A curve of conversion conductance and anode current, plotted against peak heterodyne voltage, is shown on VAD/313·17. This indicates optimum conversion with a peak oscillator voltage of 4·5 volts. Under these conditions the equivalent noise resistance referred to the mixer grid is approximately 1000 ohms.

When used at frequencies above 30 Mc/s, the impedance in the mixer anode to signal frequency can have a considerable effect on the performance. If a small inductance is included in the anode lead this is reflected as a negative resistance in the input circuit, and tends to offset the normal low input resistance of a triode mixer. The inductance is obtainable from the length of lead between the anode tag on the valve holder and the IF transformer tuning condenser. This condenser forms an effective earth return to signal frequency when the latter is considerably higher than the IF. At 100 Mc/s, about 1 in. of lead is sufficient; at 400 Mc/s the condenser should be attached to the anode tag itself. Too much inductance in the anode circuit will lead to oscillation of the mixer.

Typical circuits for frequency changer service are given on VAD/313·67. Information is given on the circuit on tuning constants for operation at 100 Mc/s and 430 Mc/s.

It is not desirable to inject heterodyne volts of such value that mixer grid current flows, as this only serves to damp the input circuit and further lower its impedance. At frequencies up to 200 Mc/s a small coupling condenser from oscillator grid to mixer grid supplies adequate heterodyne voltage. At higher frequencies, stray capacities within the valve and across the holder are of sufficient magnitude to render unnecessary any additional capacity.

The condenser C on the circuits is the normal IF tuning condenser to which reference was made in the remarks on by-passing of mixer anode to signal frequency.

4.33 Measurements taken on the mixer at 430 Mc/s indicate a noise factor of about 10 and a conversion gain of the order of 5 db. At 45 Mc/s a noise factor of the order of 8 is obtainable. Experience indicates that the 12AT7 as a mixer offers distinct advantages over a diode up to at least 450 Mc/s. Above this frequency the valve will still give useful service, but it is to be expected that a rapid falling off in efficiency occurs.

4.4 Oscillator: The valve may be used as an oscillator either single ended or in push-pull. A typical circuit is given on No. 313·68, and a curve showing the performance obtainable at frequencies up to 500 Mc/s is given on No. 313·18. Using lines for the tuned circuit one 12AT7 with the two halves in push-pull will deliver about 2 watts output at 400 Mc/s.

Under single ended conditions rather under half this power is developed, as the efficiency is not so high as with a symmetrical circuit. When used at V.H.F. either single ended or in push-pull it may be found advantageous to insert a choke in series with the cathode lead.

4.5 RF Amplifier: The 12AT7 may be used either as a grounded cathode or grounded grid amplifier. Grounded cathode operation is not normally suitable for high frequency applications as, due to the anode/grid capacity, neutralisation is needed to prevent self oscillation, and such neutralisation is difficult to maintain when wide band operation is required.

4.51 Grounded Grid Operation: A typical circuit showing the 12AT7 used either single ended or push-pull as a grounded grid amplifier is shown on No. 313·69. The input impedance single ended is:

$$R_{in} = \frac{r_a + R_a}{\mu + 1}$$

where r_a is the valve impedance and R_a the anode load. If, as is usually the case at high frequencies, the effective anode load is low compared with the anode impedance the expression reduces to $R_{in} = \frac{1}{g_m}$ which is equal to 180 ohms for the 12AT7 at V_a 250 volts and V_g —2 volts, or 150 ohms with V_a 180 volts and V_g —1 volt.

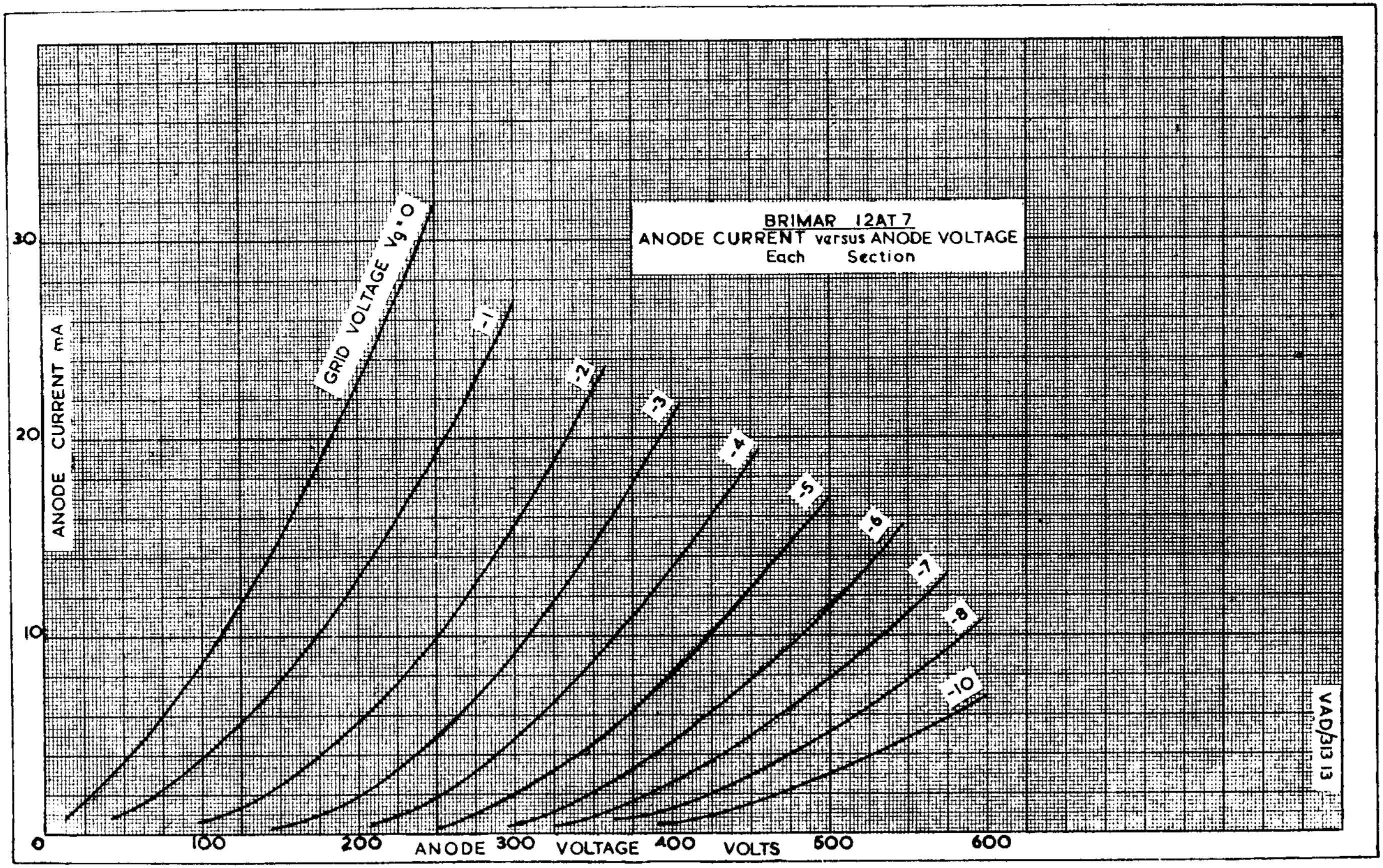
When used in push-pull the overall input impedance is approximately 360 ohms and 300 ohms respectively, which facilitates matching to a 300Ω balanced transmission line.

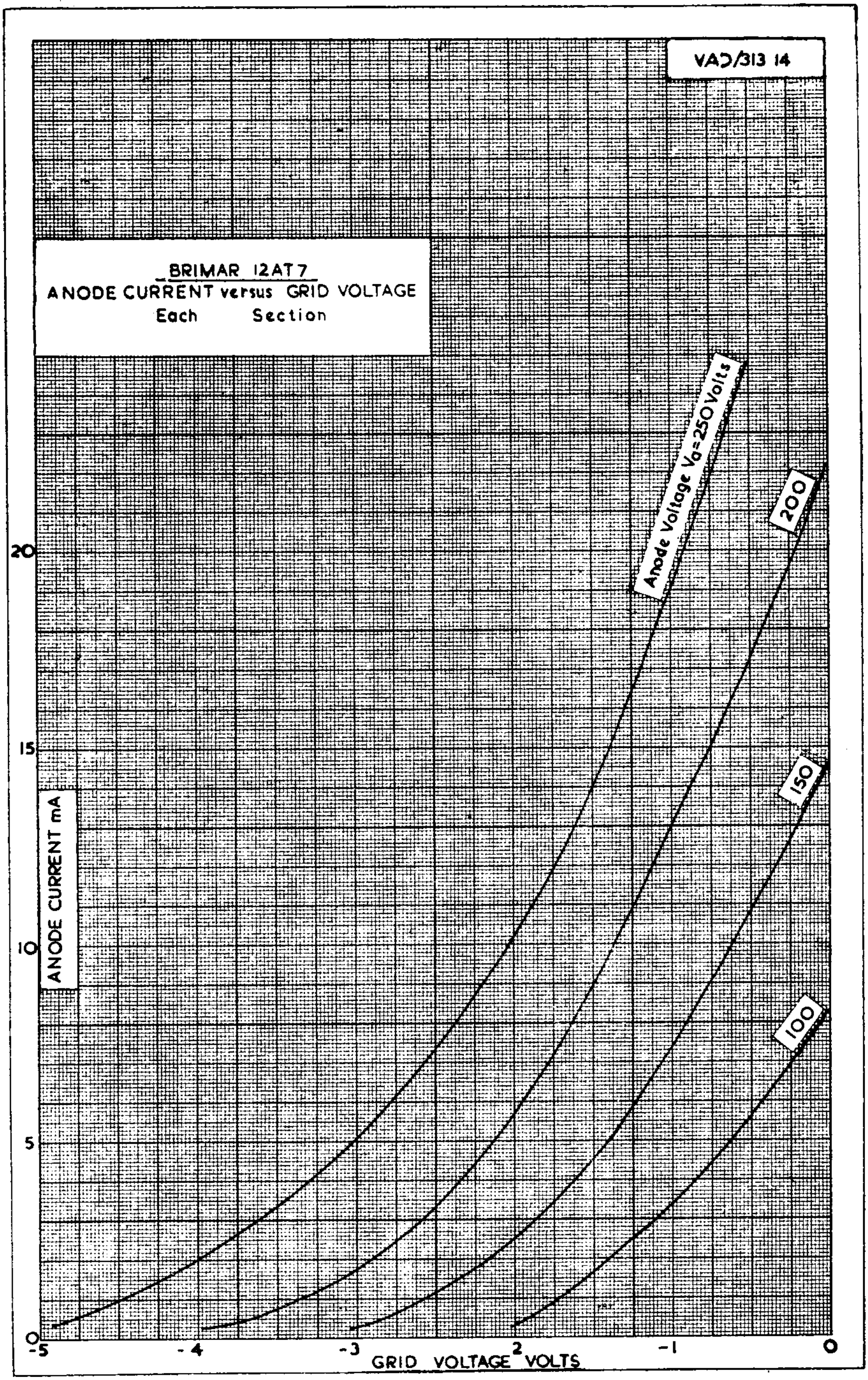
Normally neutralisation is not required with a grounded grid amplifier, as the earthed grid forms an effective screen between cathode and anode, reducing the feed-back in the valve to a sufficiently low level. At high frequencies, however, it is not easy to hold the grid completely at ground due to the inductance of the earthing lead. Furthermore, the effect of the internal valve feed-back becomes greater at high frequencies. Above 350 Mc/s it is very often necessary to resort to neutralisation, but it is not critical to adjust and the required amount can often be obtained by dressing the wiring.

A single ended grounded grid amplifier using half a 12AT7 will give a gain of about 10 db at 200 Mc/s and about 6 db at 400 Mc/s. The noise factor is of the order of 8 at 200 Mc/s. Push-pull operation gives slightly better performance as the lower capacity across the tuned circuits allows a higher L/C ratio. The improvement in gain is of the order of 2 to 3 db. At 40 Mc/s the input impedance is approximately 40 kΩ in the single ended condition.

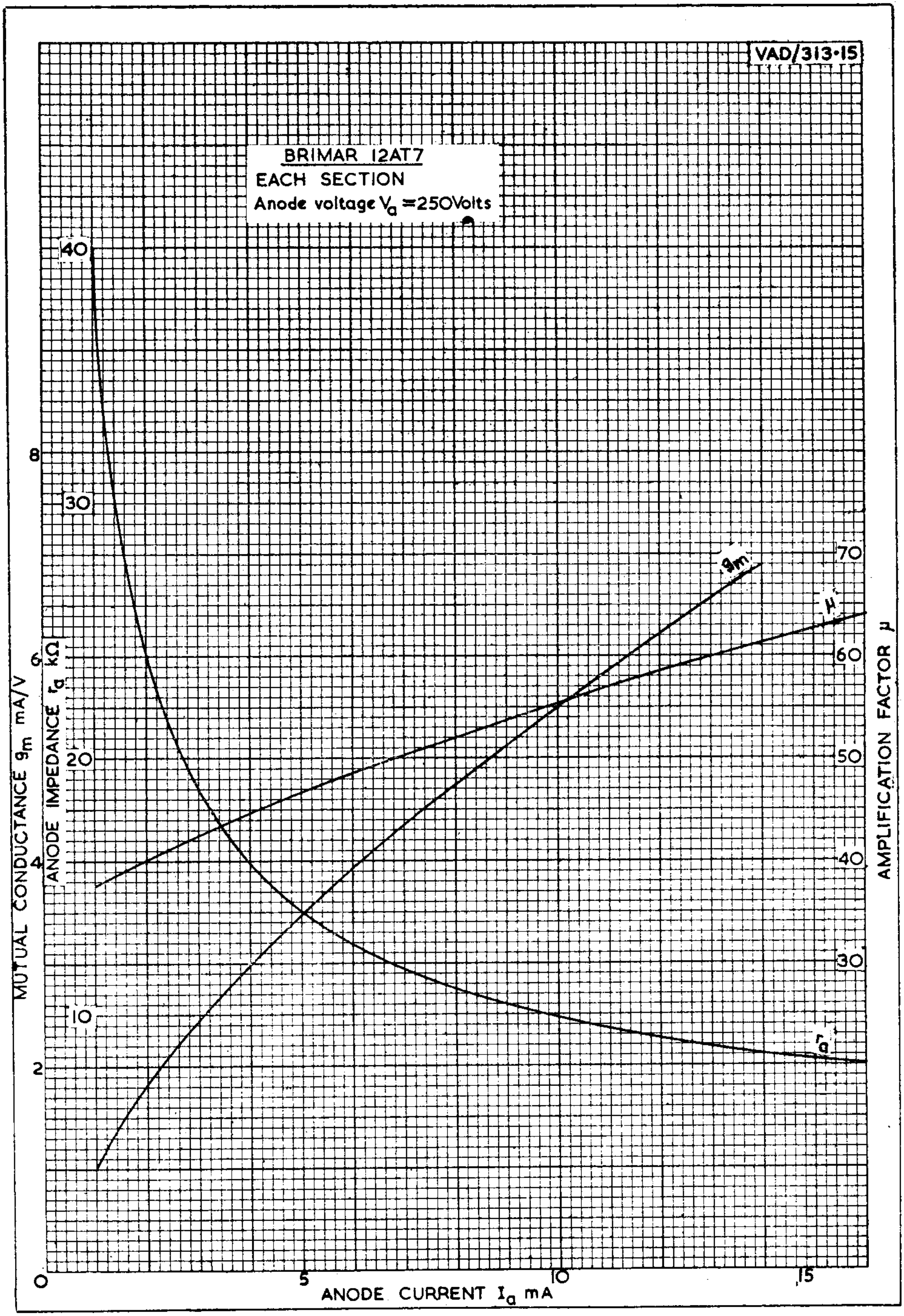
4.52 Grounded Cathode: Normally this method is not suitable at high frequencies as neutralisation is critical and difficult to maintain over a wide bandwidth. If, however, the grounded cathode amplifier is arranged to feed into a grounded grid amplifier the gain of the first stage looking into an impedance of approximately $\frac{1}{g_m}$ is unity, so that the circuit is stable. The output current of the grounded cathode stage flows in the anode circuit of the grounded grid stage so that the gain of the two stages is $g_m R_a$, where R_a is the anode load of the grounded grid stage.

A typical circuit is shown on 313·69. Neutralisation is necessary on the first stage solely to obtain minimum noise, but this is non-critical, as its application does not involve difficulties over stability. At 200 Mc/s a typical gain is 14 db with a noise factor of 7. This circuit is also useful for the first stage in a high gain IF amplifier at about 40 Mc/s.

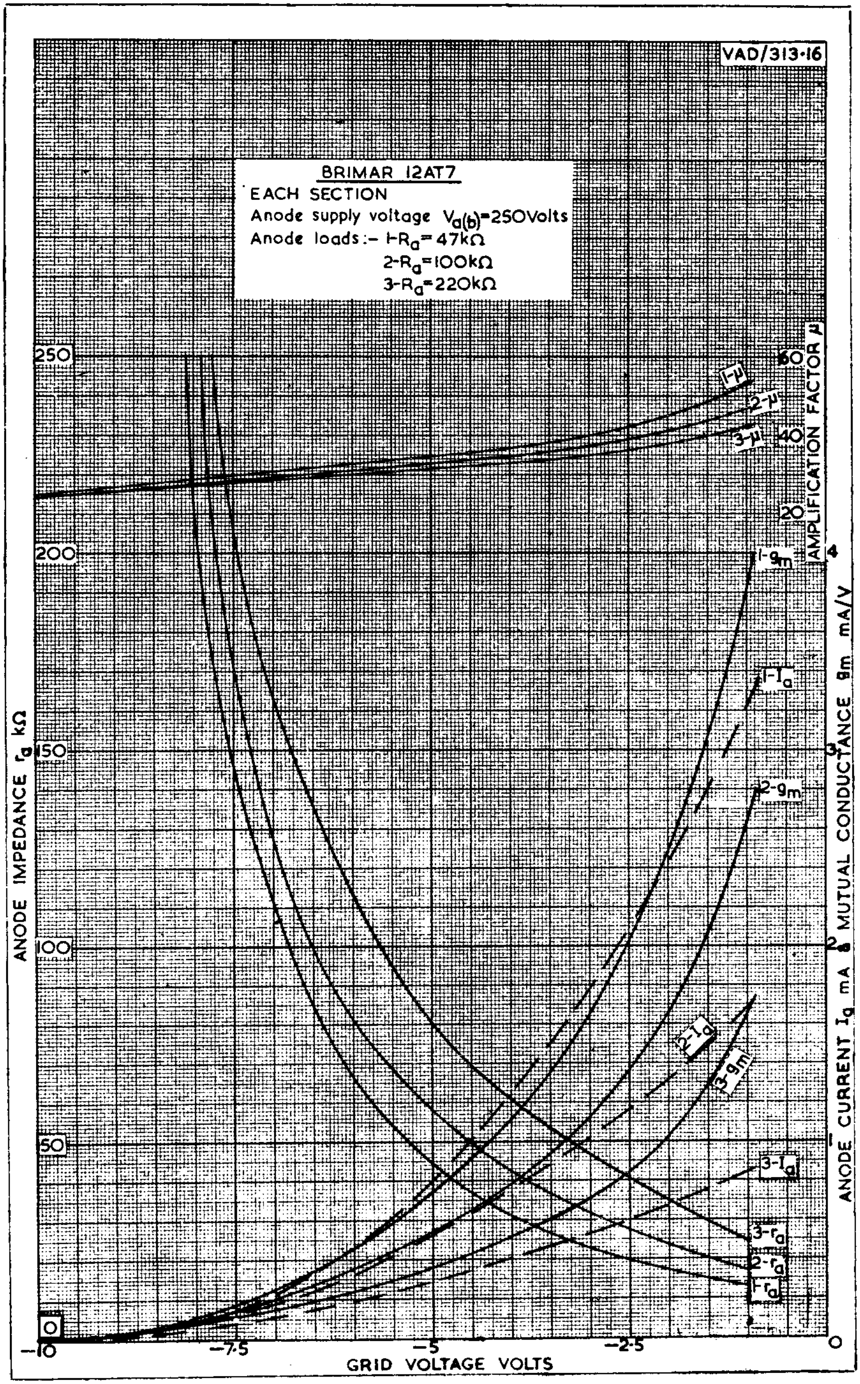

BRIMAR 12AT7
ANODE CURRENT versus ANODE VOLTAGE
Each Section
GRID VOLTAGE Vg=0
-1
-2
-3
-4
-5
-6
-7
-8
-10
ANODE CURRENT mA
30
20
10
0
100
200
300
400
500
600
ANODE VOLTAGE VOLTS
VAD/313 13



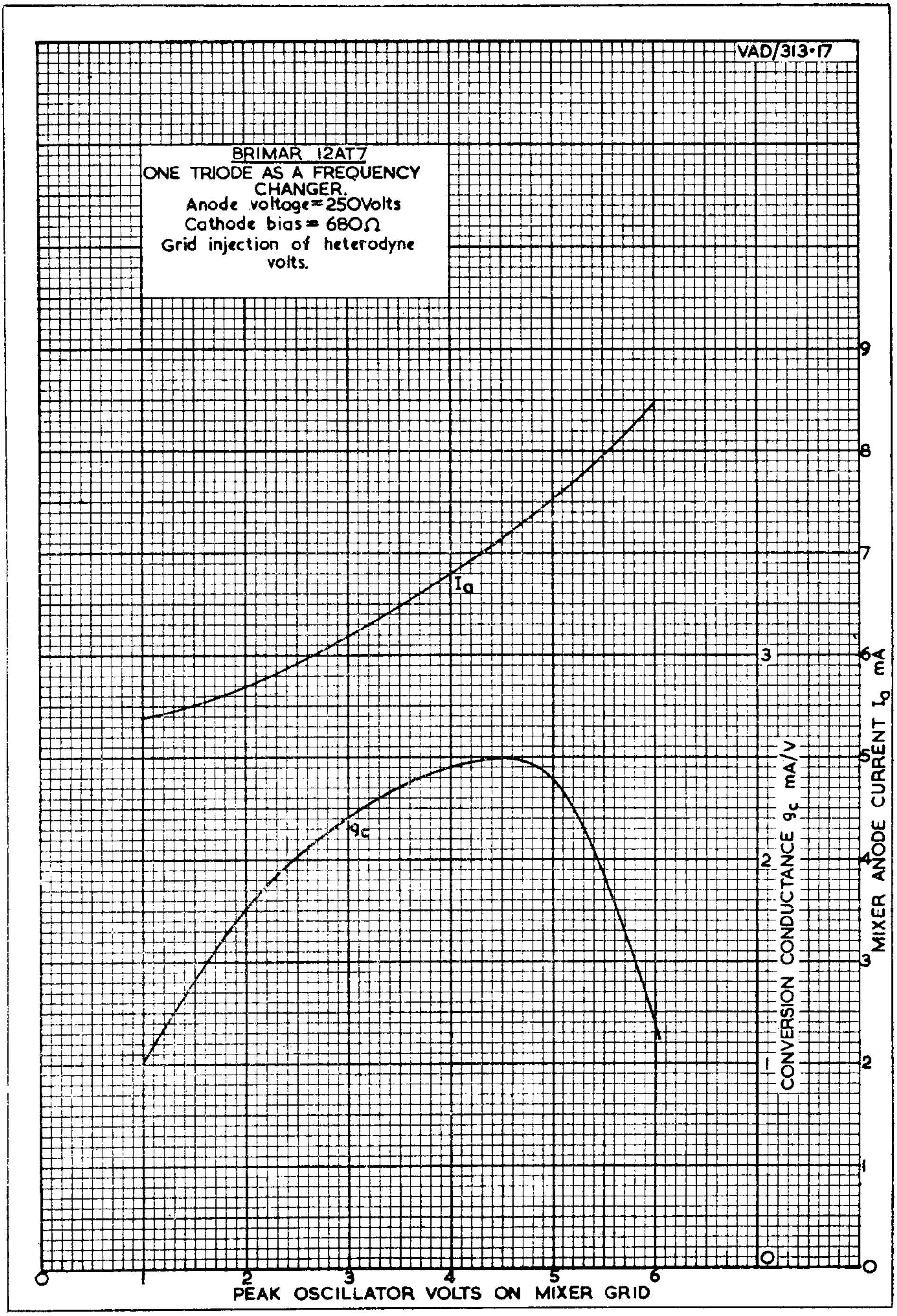
VAD/313 14
BRIMAR 12AT7
ANODE CURRENT versus GRID VOLTAGE
Each Section
Anode Voltage Va=250 Volts
200
150
100
ANODE CURRENT mA
20
15
10
5
0
-5
-4
-3
-2
-1
0
GRID VOLTAGE VOLTS



VAD/313·15
BRIMAR 12AT7
EACH SECTION
Anode voltage V_a = 250 Volts
MUTUAL CONDUCTANCE g_m mA/V
ANODE IMPEDANCE r_a kΩ
AMPLIFICATION FACTOR μ
ANODE CURRENT I_a mA
g_m
μ
r_a
0
5
10
15
2
4
6
8
10
20
30
40
30
40
50
60
70



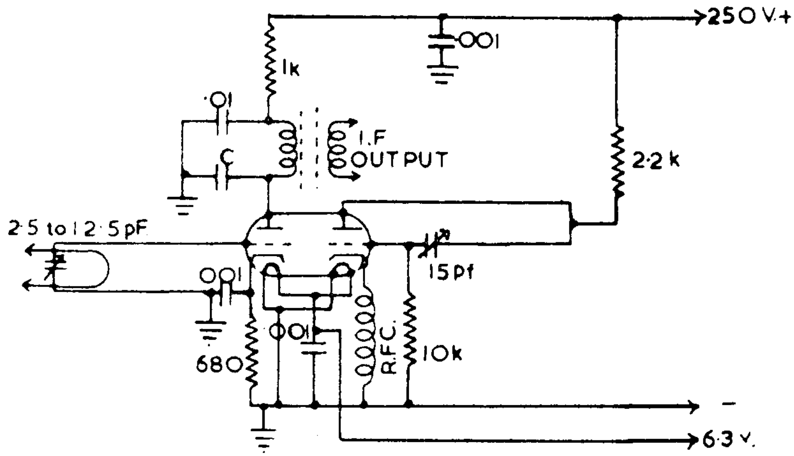
VAD/313·16
BRIMAR 12AT7
EACH SECTION
Anode supply voltage $V_{a(b)}$=250Volts
Anode loads:- 1-R_a=47kΩ
2-R_a=100kΩ
3-R_a=220kΩ
1-μ
2-μ
3-μ
1-g_m
1-I_a
2-g_m
2-I_a
3-g_m
3-I_a
3-r_a
2-r_a
1-r_a
ANODE IMPEDANCE r_a kΩ
AMPLIFICATION FACTOR μ
ANODE CURRENT I_a mA & MUTUAL CONDUCTANCE g_m mA/V
GRID VOLTAGE VOLTS



VAD/313-17
BRIMAR 12AT7
ONE TRIODE AS A FREQUENCY CHANGER.
Anode voltage = 250 Volts
Cathode bias = 680Ω
Grid injection of heterodyne volts.
I_a
g_c
PEAK OSCILLATOR VOLTS ON MIXER GRID
CONVERSION CONDUCTANCE g_c mA/V
MIXER ANODE CURRENT I_a mA
0
1
2
3
4
5
6
7
8
9

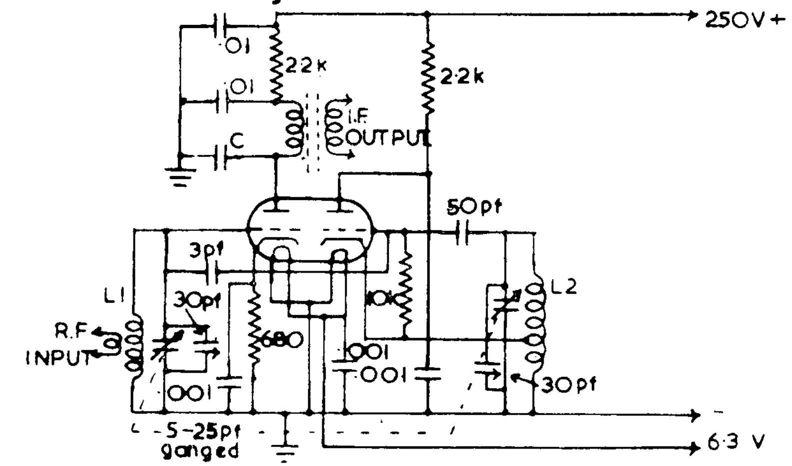
VAD/313·67

BRIMAR 12AT7 420Mc/s Frequency changer.

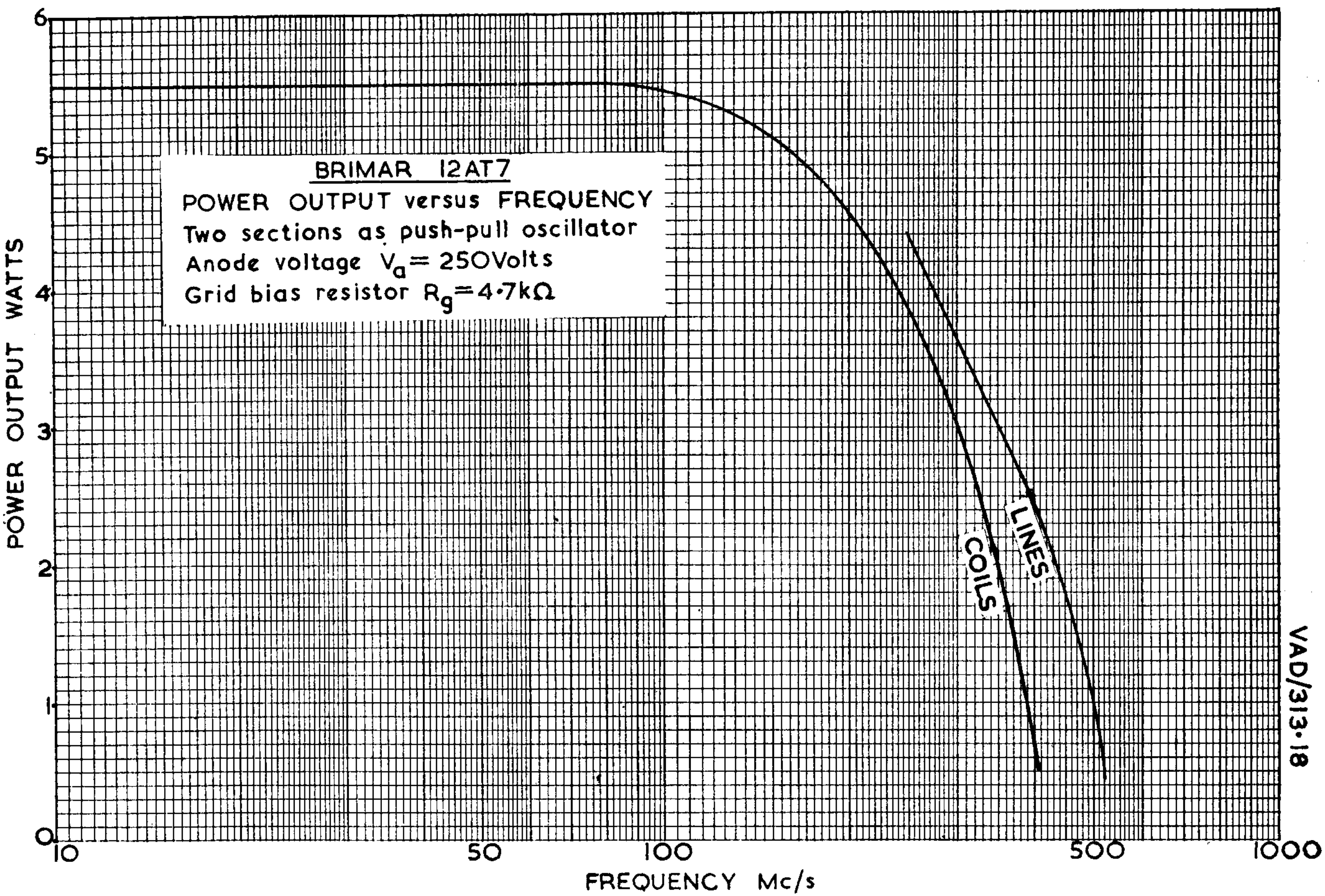


TUNED CIRCUITS PARALLEL LINES 14 S.W.G. COPPER WIRE, APPROX 2 to 2 1/2 INCHES LONG, SPACED 1/2 INCH.

Frequency changer for F.M. band 88 to 108 Mc/s.

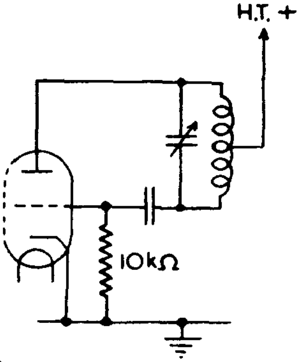


L1 2 1/4 TURNS 22 S.W.G. I.D. 3/8 in. 1/2 in. LONG. WIRE LENGTH, INCLUDING LEADS 4 3/8 in.
L2. 1 3/4 TURNS 22 S.W.G. I.D. 1/4 in. 3/16 in. LONG. WIRE LENGTH, INCLUDING LEADS, 3 3/4 in. TAP 1 TURN FROM EARTHY END.

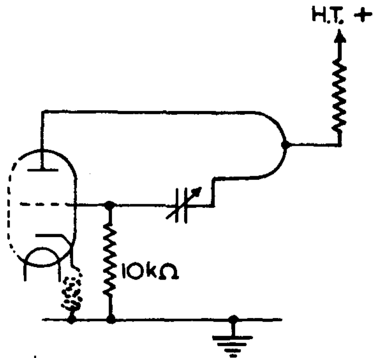

BRIMAR 12AT7
POWER OUTPUT versus FREQUENCY
Two sections as push-pull oscillator
Anode voltage V_a = 250 Volts
Grid bias resistor R_g = 4·7kΩ
LINES
COILS
POWER OUTPUT WATTS
FREQUENCY Mc/s
0
1
2
3
4
5
6
10
50
100
500
1000

VAD/313·18

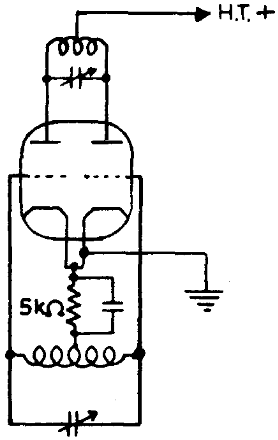
VAD/313·68



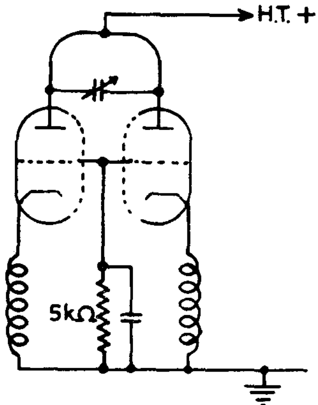
$\frac{1}{2}$ 12AT7 as a H.F Oscillator



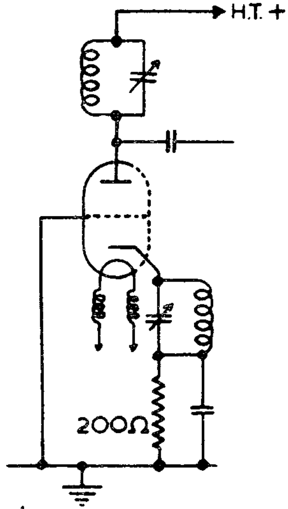
$\frac{1}{2}$ 12AT7 as a V.H.F Oscillator



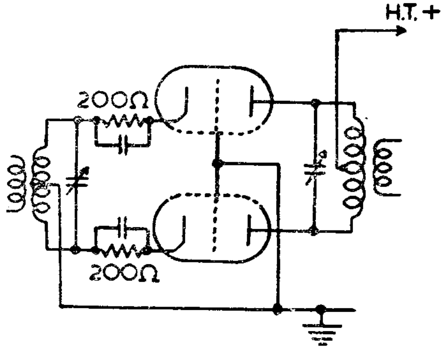
12AT7 as a push-pull H.F Oscillator



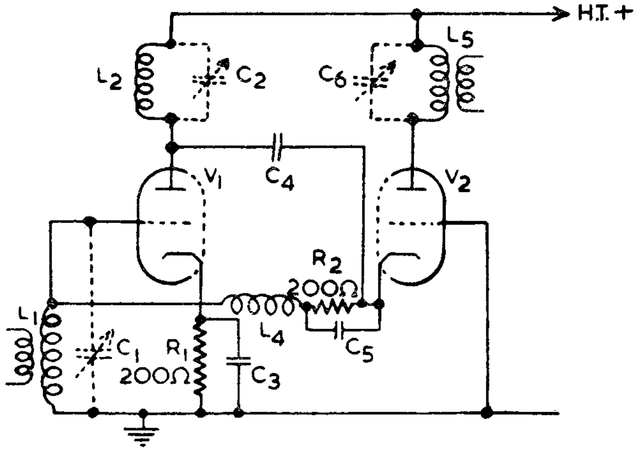
12AT7 as a push-pull V.H.F Oscillator



$\frac{1}{2}$ 12AT7 as a grounded grid amplifier



12AT7 as a push pull grounded grid amplifier



12AT7 as a grounded cathode, grounded grid amplifier

BRIMAR

RECEIVING VALVE

12AU7
ECC82

APPLICATION REPORT VAD/513.4

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

Issued August, 1950. Reprinted January, 1952.

INTRODUCTION: The Brimar type 12AU7 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, paraphase amplifier, oscillator and as a frequency multiplier.

DESCRIPTION: The valve comprises two triode units mounted side by side having separate heaters, but common heater pin connections. Each triode unit has characteristics similar to a 6C4 and the units are mounted in a standard T6½ bulb, and based with a B.V.A. standard base type B9A.

CHARACTERISTICS:

Cathode:	Indirectly heated	*Series*	*Parallel*	
	Voltage	12·6	6·3	volts
	Nominal Current	0·15	0·3	ampere
	Max. Heater-Cathode potential (DC)	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	2·75 watts
Max. Anode Current	20 mA
Max. Negative Control Grid Voltage	150 volts
Max. Average Grid Current	5 mA
Max. Grid Circuit Resistance (autobias)	1 megohm
Max. Grid Circuit Resistance (fixed bias)	0·25 megohm

Capacities (approx.):*

	Triode Unit ′	*Triode Unit ″*	
$c_{g,a}$	1·5	1·5	pF
$c_{g,k}$	1·6	1·6	pF
$c_{a,k}$	0·5	0·35	pF
$c_{h,k}$	4·5		pF
$c_{a',a''}$	0·7		pF
$c_{g',g''}$	0·004		pF
$c_{g',a''}$	0·035		pF
$c_{g'',a'}$	0·02		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 voltages (I_a/V_a) (Curve No. 313·20).

Anode Current plotted against grid voltage for various anode voltages (I_a/V_g) (Curve No. 313·21).

Mutual conductance, amplification factor and anode impedance plotted against anode current (g_m/I_a) (Curve No. 313·22).

TYPICAL OPERATION

Class AI Amplifier:

Heater	6·3	6·3	volts
Anode	100	250	volts
Grid	0	—8·5	volts
Amplification Factor (μ)	19·5	17	
Anode Impedance (r_a)	6250	7700	ohms
Mutual Conductance	3·1	2·2	mA/V
Anode Current	11·8	10·5	mA

Push-Pull Class AI Amplifier: The valve provides a very satisfactory push-pull stage for power outputs up to 1200 Milliwatts and is suitable for driving a Class "AB2" and Class "B" amplifier stage, such as a pair of 6BW6 valves or a 5763.

A curve, VAD/313·24, is attached to this report, which shows the harmonic distortion plotted against power output, for operating conditions of anode volts 300, grid volts —11·5, output load 10,000 ohms, and anode volts 250, grid volts —9·5, output load 15,000 ohms. The maximum outputs shown are those obtainable in Class AI, i.e. up to the point where grid current commences.

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 for three different supply voltages for one triode unit:

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

Anode Load (R_a megohms)	0·047		0·1		0·22	
Grid Leak (succeeding valve) (megohms)	0·1	0·22	0·22	0·47	0·47	1·0
Cathode Resistance (ohms)	1800	2000	3800	4700	9500	11500
Output Voltage (peak)	11	14	15	18	20	24
Voltage Gain	11	11	11	11	11	11

b. Anode Supply Voltage $V_{a(b)}$ 200 volts:

Anode Load (R_a megohms)	0·047		0·1		0·22	
Grid Leak (succeeding valve) (megohms)	0·1	0·22	0·22	0·47	0·47	1·0
Cathode Resistance (ohms)	1200	1400	2800	3600	8300	10000
Output Voltage (peak)	26	29	33	40	44	54
Voltage Gain	12	12	12	12	12	12

c. Anode Supply Voltage $V_{a(b)}$ 300 volts:

Anode Load (R_a megohms)	0·047		0·1		0·22	
Grid Leak (succeeding valve) (megohms)	0·1	0·22	0·22	0·47	0·47	1·0
Cathode Resistance (ohms)	1200	1500	3000	4000	8800	11000
Output Voltage Peak	52	68	68	80	82	92
Voltage Gain	12	12	12	12	12	12

A graph is attached to this report which shows the relation of the various valve parameters under conditions of resistance capacity coupling. This graph (No. VAD/313·23) is taken at an anode supply voltage $V_{a(b)}$ of 250 volts, with three values of anode load resistance, viz. 47,000, 100,000 and 220,000 ohms and plots the anode current, amplification factor, mutual conductance and anode impedance against grid voltage. From this graph the correct grid bias (cathode resistor) can be obtained, also 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 the graph.

If, for example, it is desired to use a valve at a supply voltage of 250 volts, an anode load of 100,000 ohms, and a succeeding valve grid leak of 470,000 ohms, then to determine the grid bias an inspection of the graph indicates a relatively linear portion of the curve of anode current/grid volts over the range of —1 to —11 volts, the mid point being —6 volts. At this point the anode current is 1·4 mA hence the cathode resistance should be 4250 ohms. The peak input voltage is 5 volts and the R.M.S. input 3·5 volts. Following the grid bias voltage upward it is evident that with an anode load of 100,000 ohms, the amplification factor (μ) is 15·4, and the anode impedance is 19,000 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 100,000 ohms in parallel with 470,000 ohms, or is 82,000 ohms. The stage gain is:

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

or in the above case:

$$\frac{15{\cdot}4 \times 82{,}000}{82{,}000 + 19{,}000} = 12{\cdot}5.$$

The peak input/voltage above was 5 volts, hence the peak output voltage will be this figure multiplied by the stage gain or 62·5 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 1 volt is 17 and at 11 volts is 10·5, hence the positive peaks of the signal output will be 37% less than the negative, and the distortion as this input is 12%.

Cascade Resistance Capacity Coupled Amplifier: The two triode units of the valve may be used in cascade if required, and no particular precautions are necessary to avoid instability. Grid and anode leads should not, however, be unduly long or close together and anode supply voltage decoupling requires to be similar to that used for the separate valves, such as the 6C4.

It is not recommended that a common cathode resistor be used for the two units when operated in cascade unless a condenser of very low reactance is employed.

A circuit is attached to this report (Ref. 313·60) 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 55 volts, an overall voltage gain of 150 and a frequency response within 1 dB from 50 cycles to 30 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 three circuits are described below.

a. Normal Paraphase: The circuit attached to this report (Ref. 313·61, 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 is 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 150 volts with an input for this output of 7 volts peak.

The condenser across the common cathode bias resistor may be omitted, but if so, the balance of 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 output is essential and it should be made variable.

b. **Anode-Cathode Load Phase Inverter:** 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 the 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. 313·62) gives two sets of typical values, together with figures of output voltage, gain and frequency response. These figures indicate a peak push-pull output of approximately 110 volts and an input for this output of 9 volts peak.

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 bass is improved, the treble balance deteriorates, but the maximum undistorted output is unaffected.

In this circuit the accurate matching of R3 and R4 is essential, and to a lesser extent the matching of R6 and R7, if an accurate balance of the push-pull is required.

c. **Cathode and Anode Coupled Phase Inverter:** In this application the push-pull output is obtained by connecting the cathodes of the two units together, as shown in the circuit attached to this report (Ref. 313·63). The grid of the second unit is driven from part of the anode load of the first unit R3 which part is also common to the load in the anode of the second unit. Hence there is negative feed back present in both anode and cathode circuits. 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 90 volts and an input for this voltage of 8 volts peak. This phase splitter gives less output than the other types described above (**a** and **b**), but the values of the resistances R1 and R2 and the succeeding valve grid leaks are not at all critical and may be to 20% tolerance without affecting the balance of the push-pull output. The resistance R3 should be so chosen that balance is obtained and if R3 is made variable an adjustable balance is realised; the balance is also unaffected by frequency.

Cathode Follower: Either, or both triodes may be employed as required as a cathode follower, but care should be exercised not to exceed the ratings given on page 2.

Oscillator: The valve functions excellently as an oscillator either utilising one unit for such purpose or both units in push-pull or in parallel.

As an oscillator the anode voltage should not exceed 300 volts and the DC grid current in the grid of either unit should not exceed 5 mA. The power output from each unit in general will be of the order of 2·5 watts maximum depending upon the circuit and frequency. The curve (Ref. 313·25) shows the relation between the power output obtainable and the frequency for both units as a push-pull oscillator.

Driven Amplifier: If this valve is employed as a driven Class C amplifier the ratings on page 2 must not be exceeded. Neutralisation will normally be required.

Frequency Multiplier: When used in this application the ratings given on page 2 apply and within these ratings quite a useful output as drive to a succeeding stage is obtained. Below are typical operating conditions of one section as a frequency doubler, and as a frequency trebler, the fundamental input being obtained from the other unit as an oscillator or multiplier. When used for a low power transmitter or receiver frequency changer the output is defined as a grid drive in mA in a stated value of grid resistor of the succeeding stage.

a. RF Doubler: Continuous ratings as a doubler without modulation.

DC Anode Voltage	250 volts
DC Grid Voltage	—108 volts
DC Grid Resistor	47,000 ohms
Peak RF Grid Voltage	120 volts
DC Anode Current	16 mA
DC Grid Current	2·3 mA
Succeeding Valve Grid Resistor	22,000 ohms
Succeeding Valve Grid Drive	6 mA*

* Measured with typical coil doubling from 45 Mc/s.

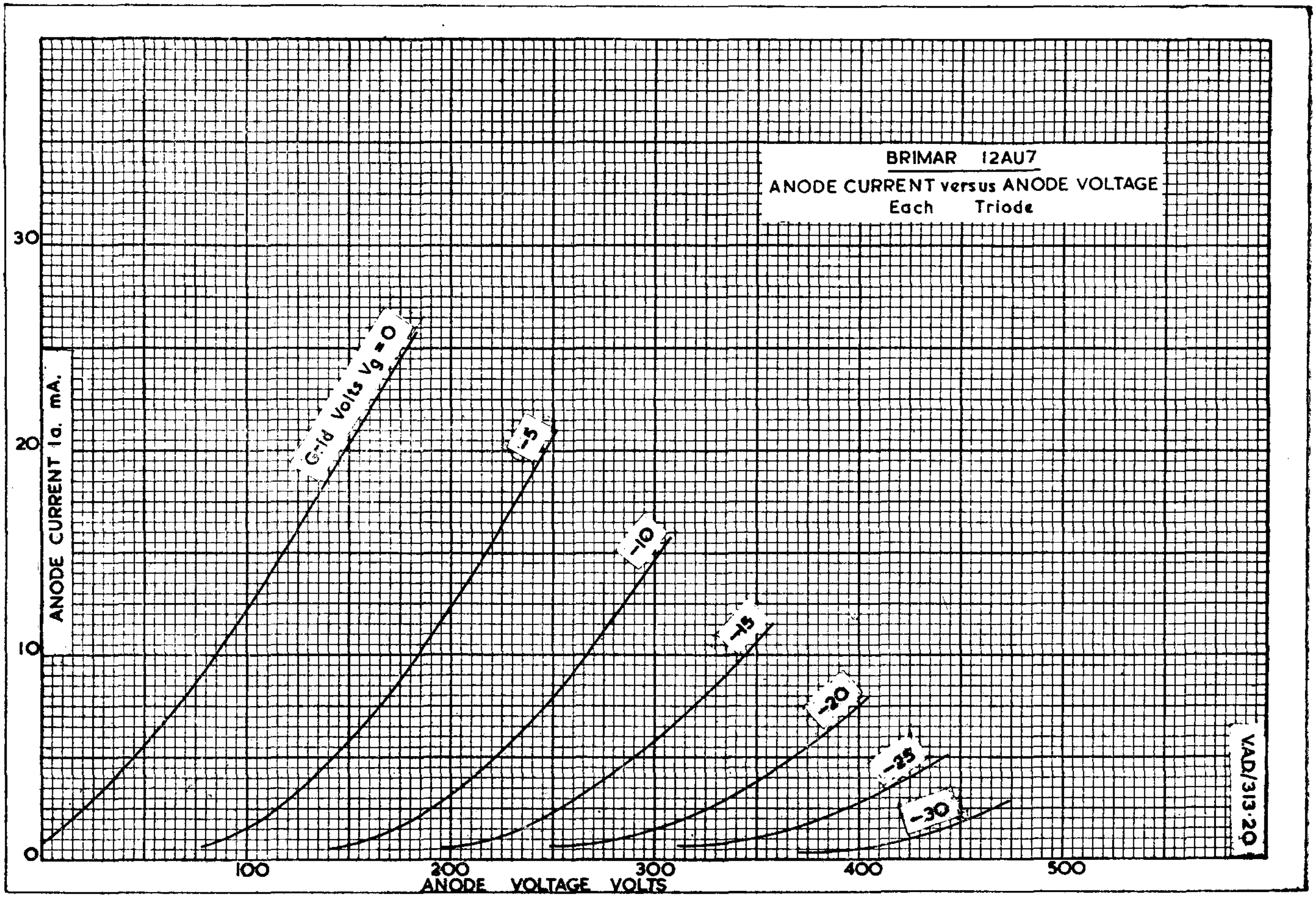
b. RF Trebler: Continuous ratings as an RF trebler without modulation.

DC Anode Voltage	250 volts
DC Grid Voltage	—124 volts
DC Grid Resistor	62,000 ohms
Peak RF Grid Voltage	140 volts
DC Anode Current	16 mA
DC Grid Current	2·0 mA
Succeeding Valve Grid Resistor	22,000 ohms
Succeeding Valve Grid Drive	2·5 mA*

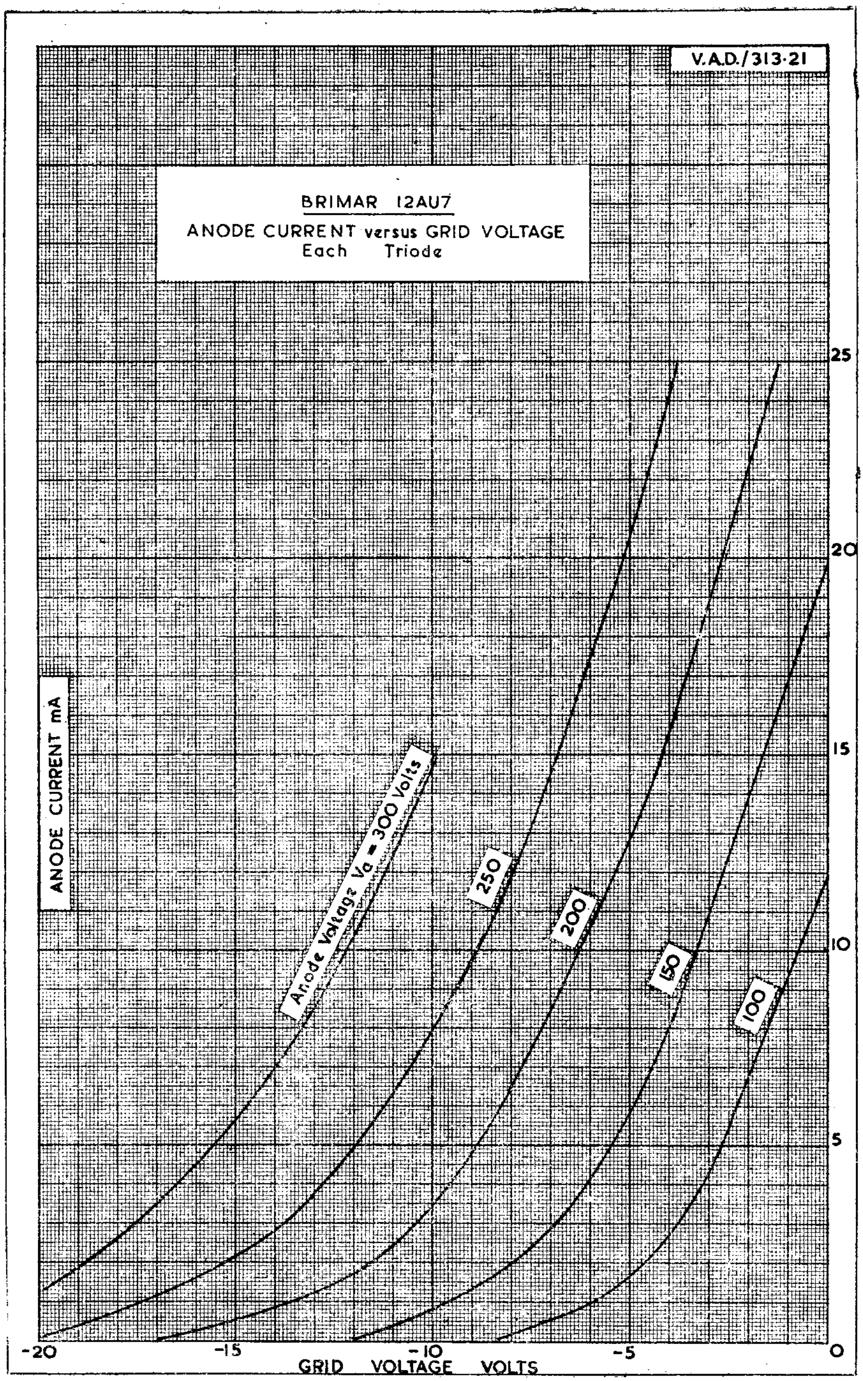
* Measured with typical coil trebling from 30 Mc/s.

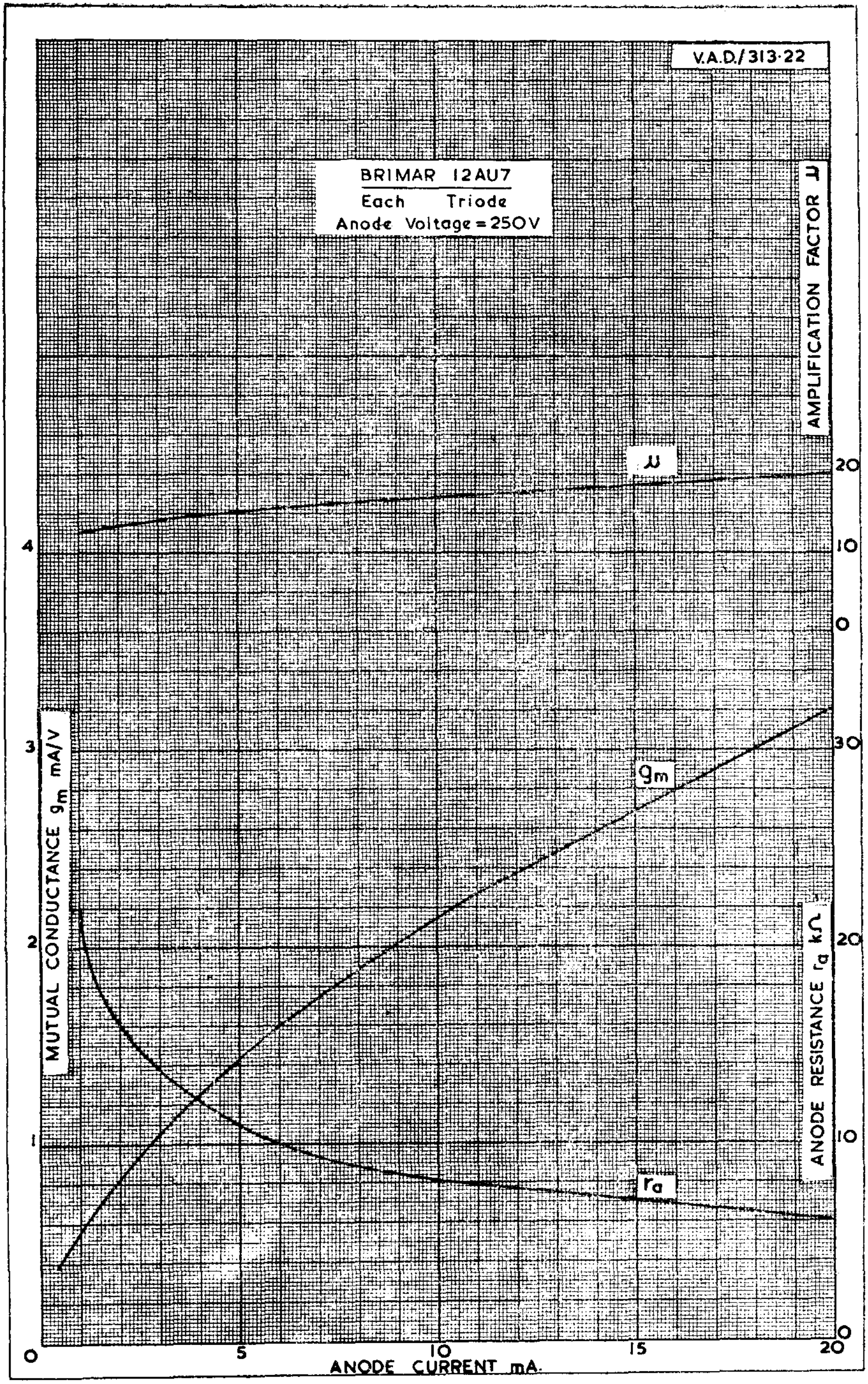
TELEVISION RECEIVERS

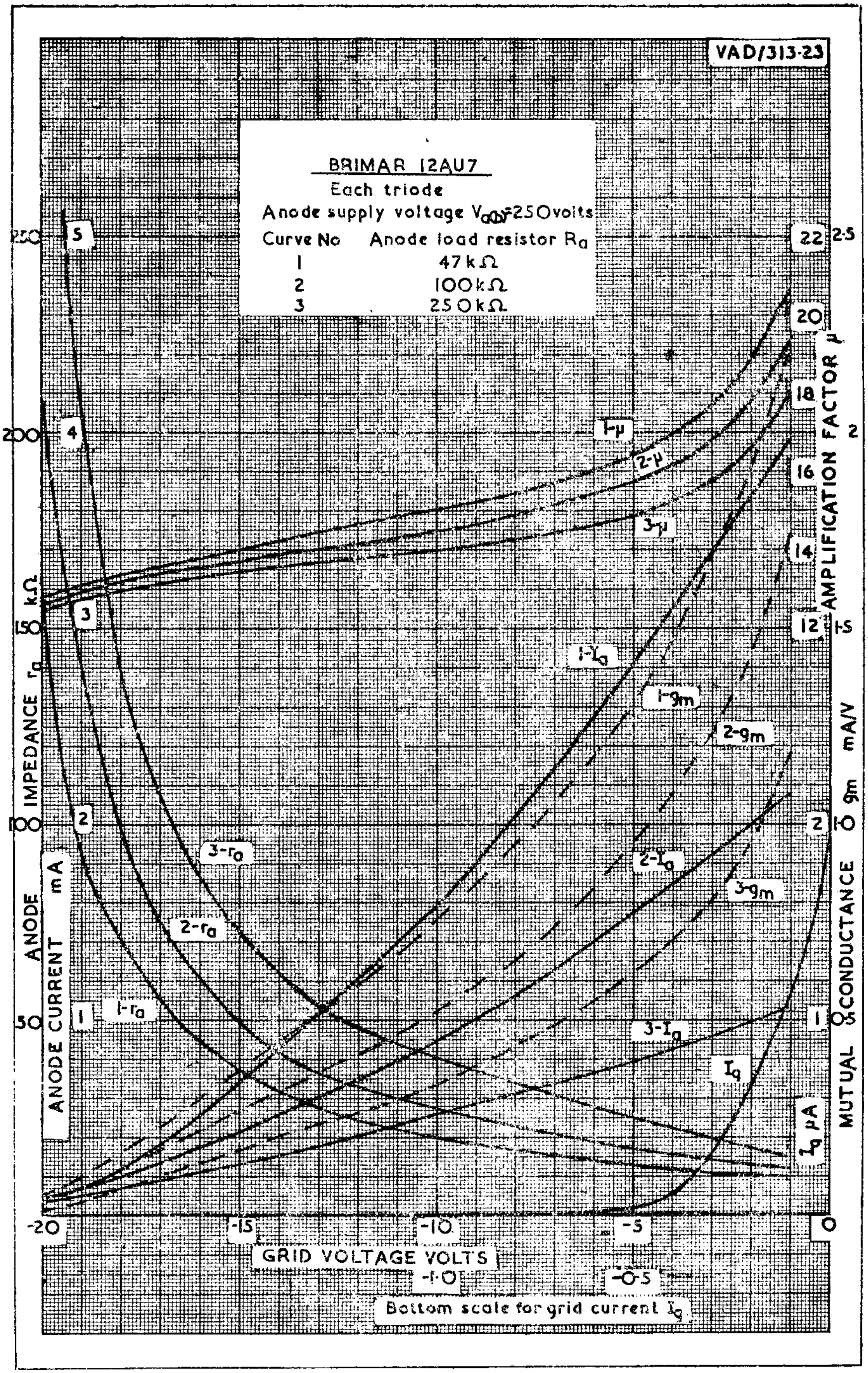
The valve may be usefully employed in television time base circuits as combined frame and line squegging oscillators or as a combined frame oscillator and output stage if suitable circuits and frame scanning coils are employed. If necessary the two sections may be used in parallel in frame scan circuits of lower efficiency, or where more power is essential.



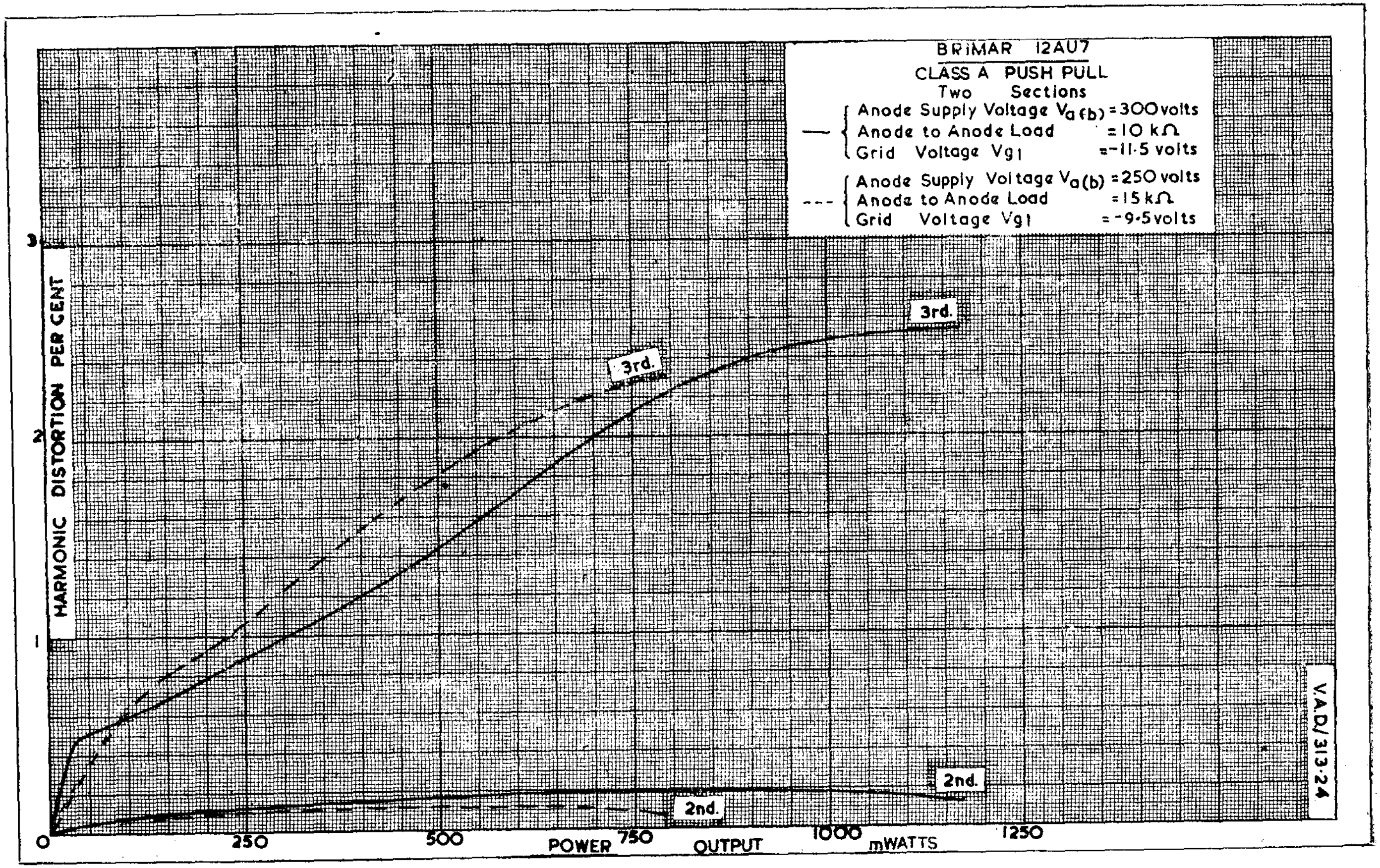
BRIMAR 12AU7
ANODE CURRENT versus ANODE VOLTAGE
Each Triode
Grid Volts Vg = 0
-5
-10
-15
-20
-25
-30
ANODE CURRENT Ia. mA.
ANODE VOLTAGE VOLTS
0
10
20
30
100
200
300
400
500
VAD/313·20


V.A.D./313·21
BRIMAR 12AU7
ANODE CURRENT versus GRID VOLTAGE
Each Triode
ANODE CURRENT mA
Anode Voltage Va = 300 Volts
250
200
150
100
25
20
15
10
5
0
-20
-15
-10
-5
GRID VOLTAGE VOLTS

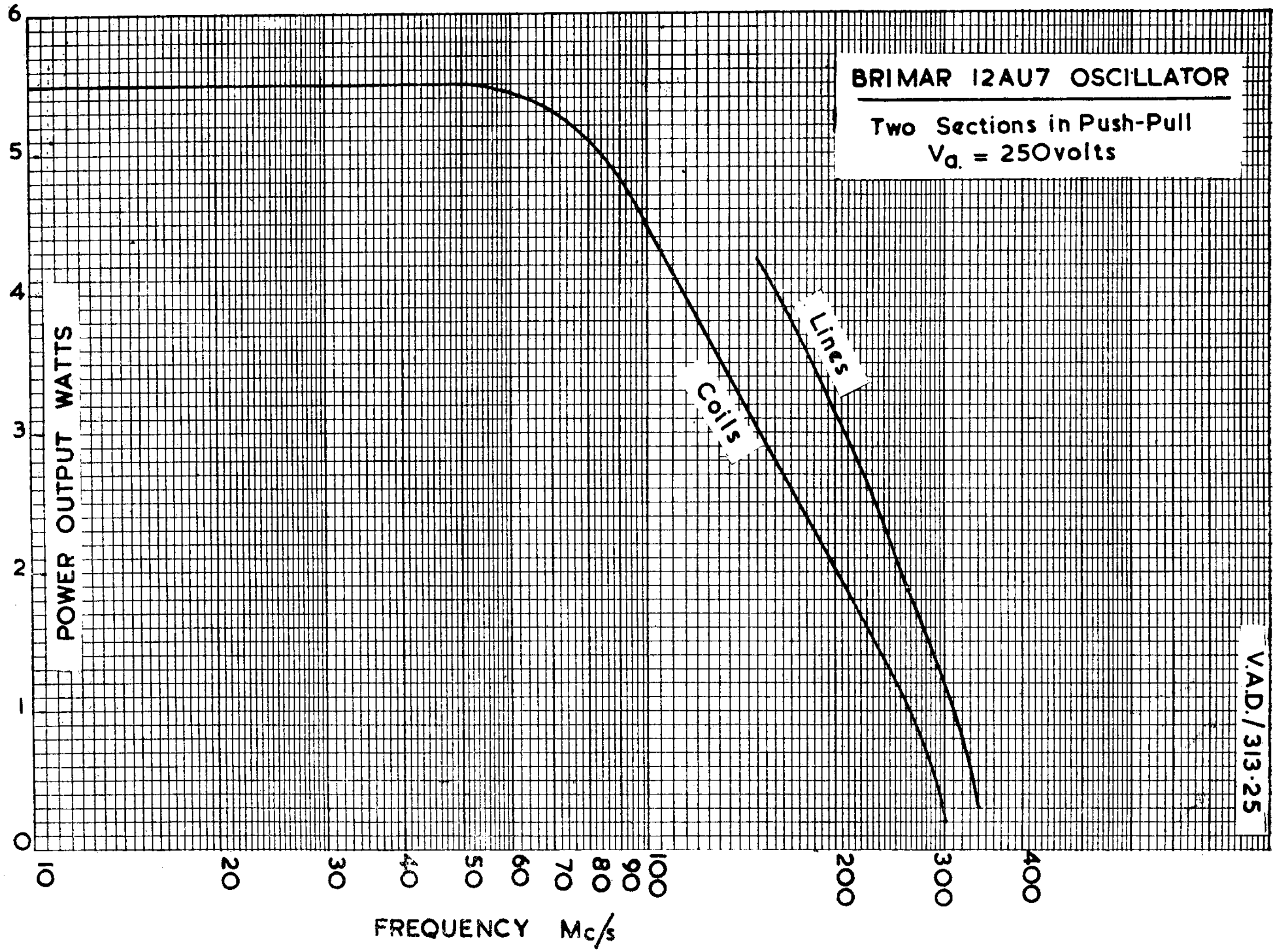

V.A.D./313·22
BRIMAR 12AU7
Each Triode
Anode Voltage = 250V
AMPLIFICATION FACTOR μ
μ
g_m
r_a
MUTUAL CONDUCTANCE g_m mA/V
ANODE RESISTANCE r_a kΩ
ANODE CURRENT mA.
0
5
10
15
20
1
2
3
4
0
10
20
30
0
10
20



VAD/313-23
BRIMAR 12AU7
Each triode
Anode supply voltage Va(b)=250volts
Curve No Anode load resistor Ra
1 47kΩ
2 100kΩ
3 250kΩ
1-μ
2-μ
3-μ
1-Ia
1-gm
2-gm
2-Ia
3-gm
3-Ia
Ig
3-ra
2-ra
1-ra
IMPEDANCE ra kΩ
ANODE CURRENT mA
AMPLIFICATION FACTOR μ
MUTUAL CONDUCTANCE gm mA/V
Ig μA
GRID VOLTAGE VOLTS
-20
-15
-10
-5
0
-1·0
-0·5
Bottom scale for grid current Ig
250
200
150
100
50
22
20
18
16
14
12
2
1
2·5
1·5
1·0
0·5

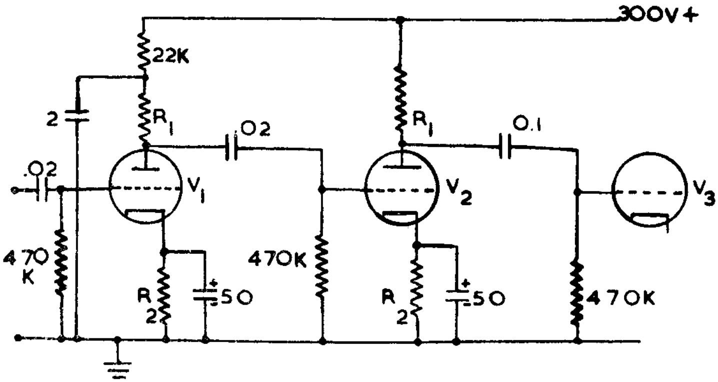


BRIMAR 12AU7
CLASS A PUSH PULL
Two Sections
Anode Supply Voltage Va(b) = 300 volts
Anode to Anode Load = 10 kΩ
Grid Voltage Vg1 = -11·5 volts
Anode Supply Voltage Va(b) = 250 volts
Anode to Anode Load = 15 kΩ
Grid Voltage Vg1 = -9·5 volts
3rd.
3rd.
2nd.
2nd.
HARMONIC DISTORTION PER CENT
1
2
3
0
250
500
750
1000
1250
POWER OUTPUT mWATTS
V.A.D/313·24


BRIMAR 12AU7 OSCILLATOR
Two Sections in Push-Pull
Va. = 250volts
V.A.D./313·25
POWER OUTPUT WATTS
FREQUENCY Mc/s
Lines
Coils
0
1
2
3
4
5
6
10
20
30
40
50
60
70
80
90
100
200
300
400

BRIMAR 12AU7

CASCADE AMPLIFIER RESISTANCE-CAPACITY COUPLED



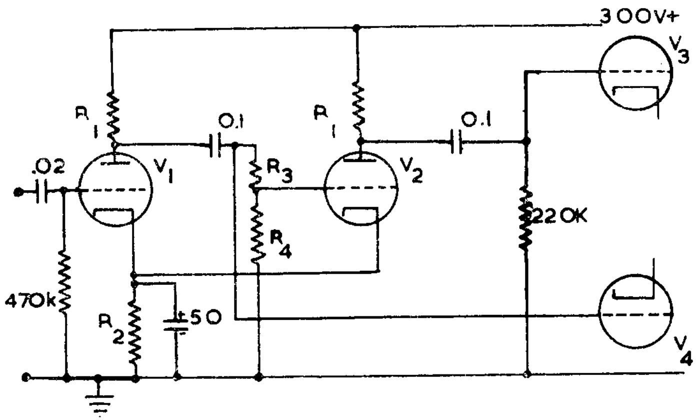
V_1 and V_2 are two units of 12AU7.

V_3 is succeeding stage or output valve.

	Condition 1	*Condition* 2	
R_1	100,000	220,000	ohms
R_2	2,200	6,800	ohms
Voltage Gain at 1 kc	174	155	
Max. R.M.S. Output Voltage for 5% Total Harmonic Distortion at 1 kc	40	40	volts
Gain at 50 c/s (compared with 1 kc)	—0·35	—0·35	dB
Gain at 30 kc (compared with 1 kc)	—0·35	—0·85	dB

BRIMAR 12AU7

PARAPHASE AMPLIFIER



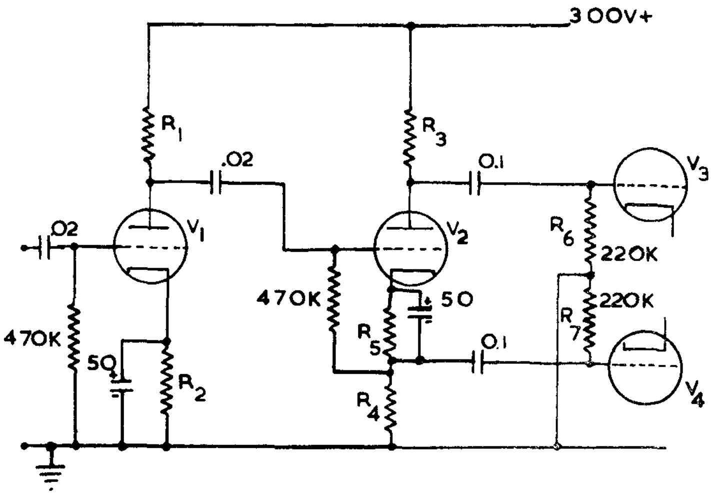
V_1 and V_2 are two units of 12AU7.

V_3 and V_4 are succeeding push-pull stage.

	Condition 1	*Condition 2*	
R_1	100,000	220,000	ohms
R_2	1,000	680	ohms
R_3	220,000	220,000	ohms
R_4	33,000	33,000	ohms
Voltage Gain at 1 kc	12·2	10·9	
Max. R.M.S. Output Voltage for 5% Total Harmonic Distortion at 1 kc (grid to grid)	110	120	volts
Gain at 30 kc/s (compared with 1 kc)	—0·66	—1·25	dB
Gain at 50 c/s (compared with 1 kc)	—0·33	—0·15	dB

BRIMAR 12AU7

VOLTAGE AMPLIFIER AND PHASE INVERTER



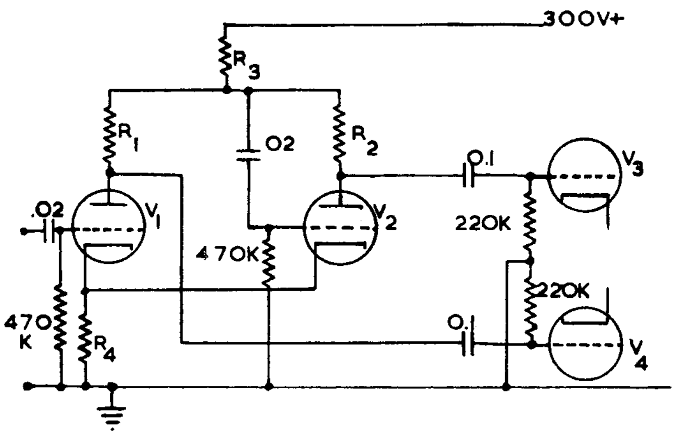
V_1 and V_2 are two units of 12AU7.

V_3 and V_4 are succeeding push-pull stage.

	Condition 1	*Condition* 2	
R_1	100,000	220,000	ohms
R_2 and R_5	2,200	6,800	ohms
R_3 and R_4	47,000	100,000	ohms
Voltage Gain at 1 kc	12·1	10·4	
Max. R.M.S. Output Voltage for 5% Total Harmonic Distortion at 1 kc (grid to grid)	80	75	volts
Gain at 50 c/s (compared with 1 kc)	—0·7	—0·25	dB
Gain at 30 kc (compared with 1 kc)	—0·85	—2·0	dB

BRIMAR 12AU7

PHASE INVERTER CATHODE AND ANODE COUPLED



V_1 and V_2 are two units of 12AU7.

V_3 and V_4 are succeeding push-pull stage.

	Condition 1	*Condition* 2	
R_1	47,000	100,000	ohms
R_2	70,000	150,000	ohms
R_3	10,000	22,000	ohms
R_4	680	1,500	ohms
Voltage Gain at 1 kc	11·4	11·0	
Max. R.M.S. Voltage for 5% Total Harmonic Distortion at 1 kc (grid to grid)	65	60	volts
Gain at 50 c/s (compared with 1 kc)	—0·55	—0·6	dB
Gain at 30 kc/s (compared with 1 kc)	0	0	dB

BRIMAR

RECEIVING VALVE

12AX7
ECC83

APPLICATION REPORT VAD/513.5

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

Issued March, 1950. Reprinted January, 1952.

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	*Series*	*Parallel*	
	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.

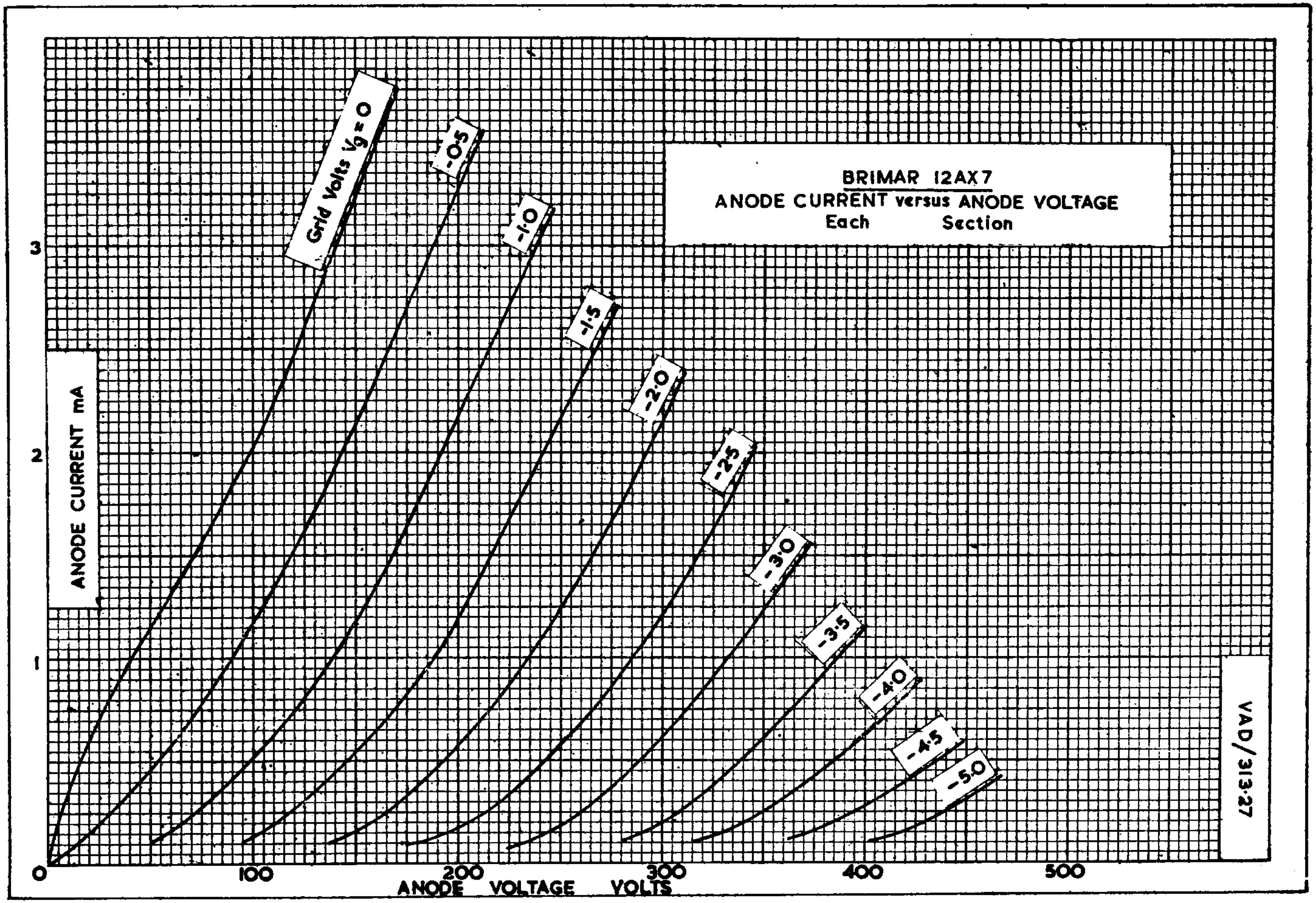
The condenser across the common cathode bias resistor may be omitted but, if so, the balance at the higher frequencies is not so good.

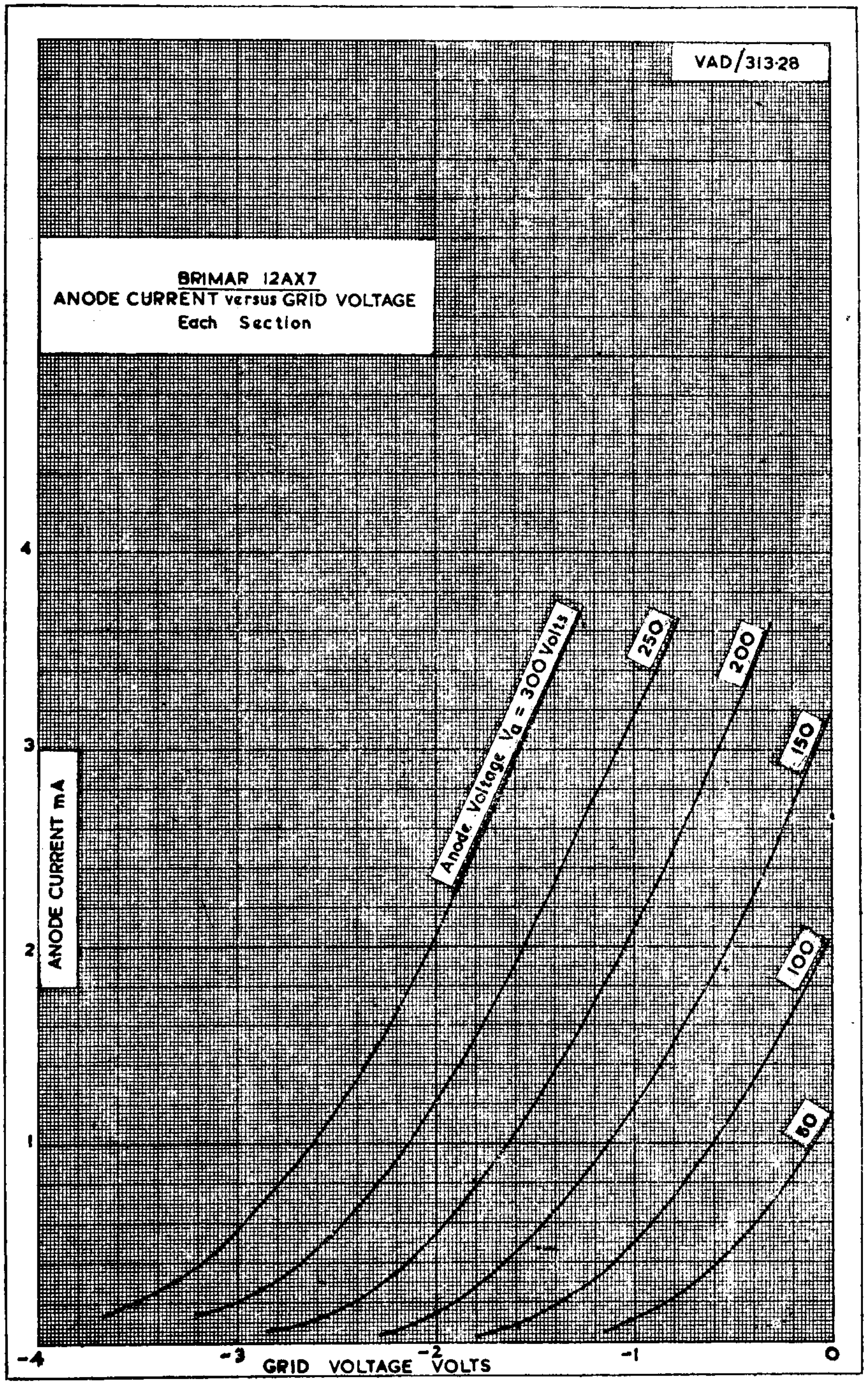
In this circuit the potentiometer tapping down the grid of the second triode unit is critical; if an accurate balance of the push pull is essential it should be made variable.

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.

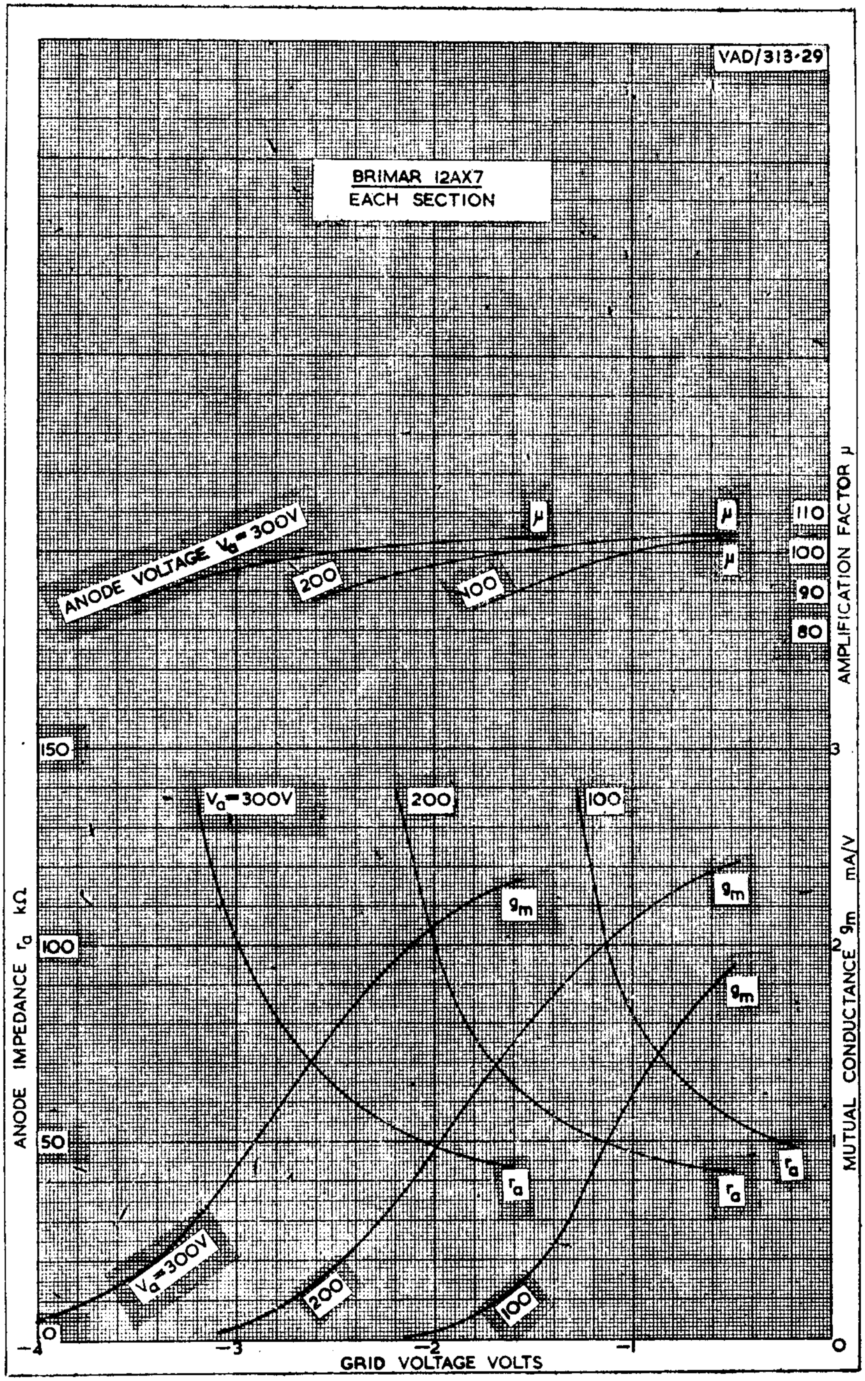
The condenser across the cathode resistor of the second unit may be omitted if desired. Its removal results in about 0·5 dB. loss of gain only, and the frequency response is slightly improved. The balance in the base is improved, the treble balance is worsened but the maximum undistorted output is unaffected.

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.

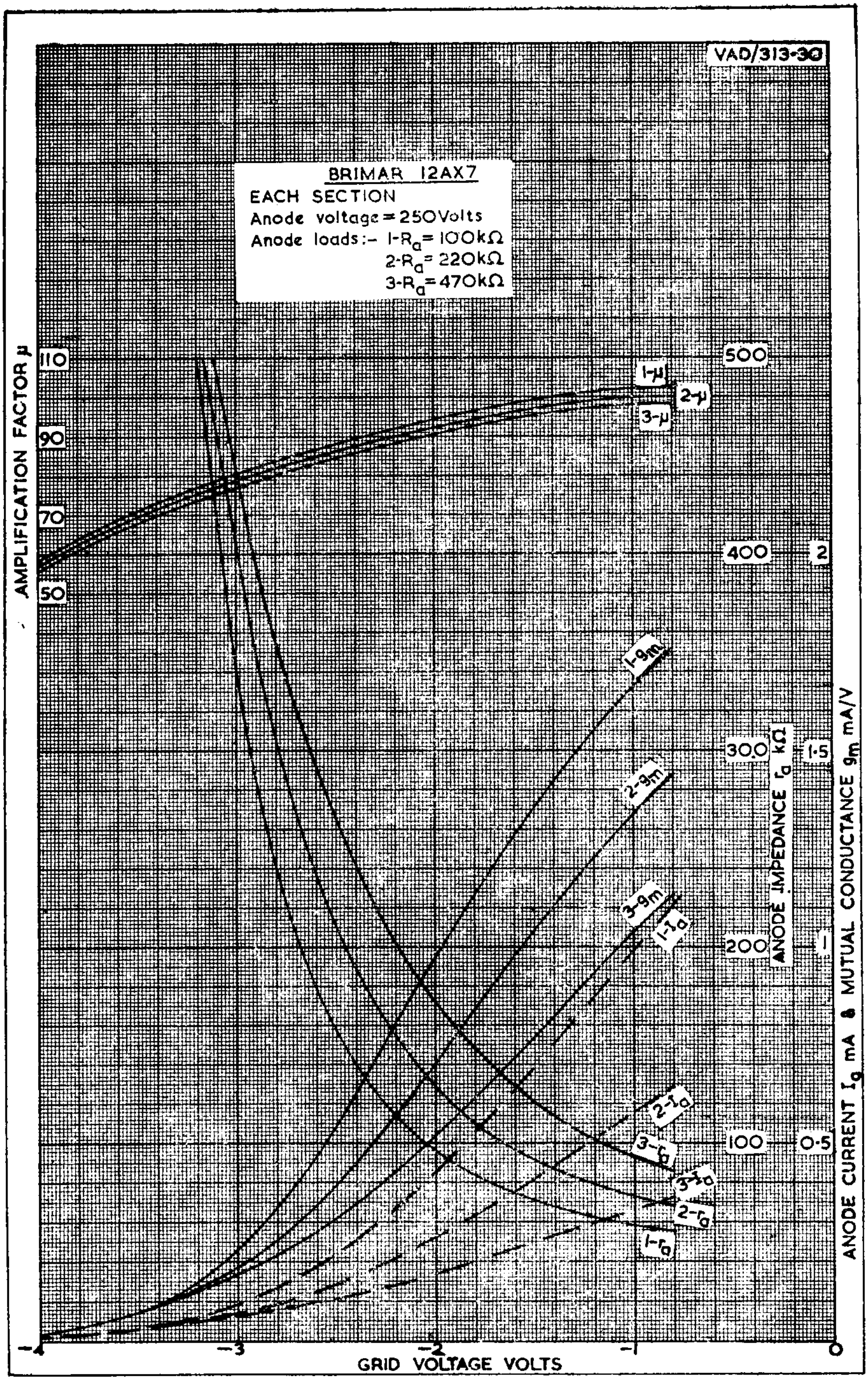

BRIMAR 12AX7
ANODE CURRENT versus ANODE VOLTAGE
Each Section
ANODE CURRENT mA
ANODE VOLTAGE VOLTS
Grid Volts Vg = O
-0·5
-1·0
-1·5
-2·0
-2·5
-3·0
-3·5
-4·0
-4·5
-5·0
0
1
2
3
100
200
300
400
500
VAD/313·27



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



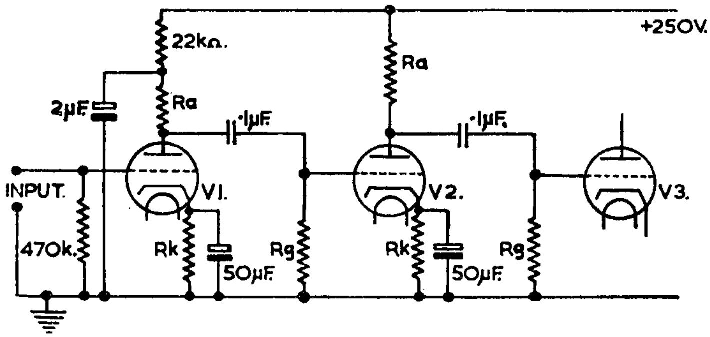
VAD/313-29
BRIMAR 12AX7
EACH SECTION
ANODE VOLTAGE Va=300V
200
100
μ
μ
μ
110
100
90
80
AMPLIFICATION FACTOR μ
150
100
50
0
ANODE IMPEDANCE ra kΩ
Va=300V
200
100
gm
gm
gm
ra
ra
ra
Va=300V
200
100
3
2
1
0
MUTUAL CONDUCTANCE gm mA/V
−4
−3
−2
−1
GRID VOLTAGE VOLTS



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

BRIMAR 12AX7

RESISTANCE-CAPACITY COUPLED CASCADE AMPLIFIER

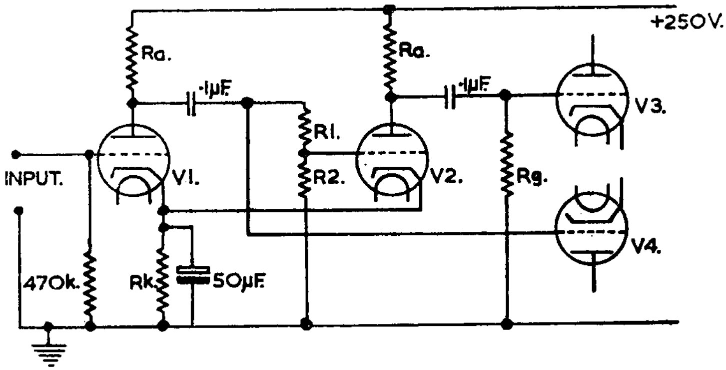


V_1 and V_2 are two units of 12AX7.
V_3 is the succeeding stage.

	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

BRIMAR 12AX7

PARAPHASE AMPLIFIER



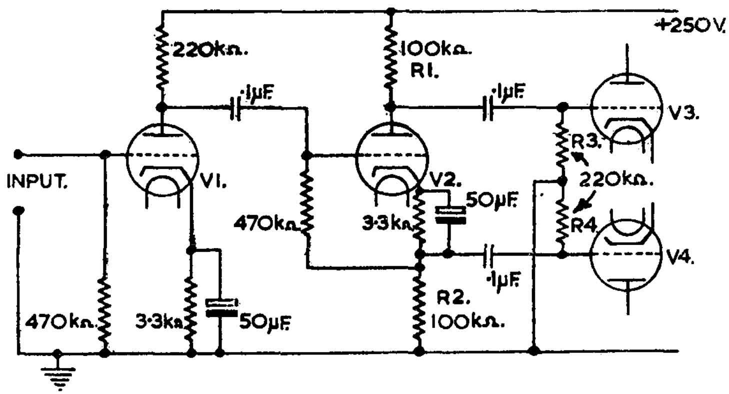
V_1 and V_2 are two units of 12AX7.

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

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

BRIMAR

RECEIVING VALVE

35W4

APPLICATION REPORT VAD/501.6

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

Issued May, 1950. Reprinted January, 1952.

INTRODUCTION: The Brimar type 35W4 is a miniature indirectly heated half wave rectifier having a 150 mA Heater intended for use in series with other valves having a similar heater current, such as in AC/DC equipment. Provision of a heater tap enables a dial lamp to be operated across a portion of the heater.

DESCRIPTION: The valve consists of a half wave rectifier unit having an indirectly heated cathode, the cathode being insulated from the heater. The unit is mounted in a standard T5½ bulb and is based with a B7G B.V.A. Standard base.

CHARACTERISTICS:

Cathode:	*Without Dial Lamp*	*With Dial Lamp*	
Indirectly Heated Voltage (nominal) Pins 3 and 4	35	32	volts
Voltage (nominal) Lamp Section Pins 4 and 6	7·5	5·5	volts
Current	0·15	0·15	ampere*
Max. DC Heater-Cathode potential	330	330	volts

* The heater current should not vary more than 5% from the rated value at any time, particularly is this important if the valve is used near its maximum ratings.

Dimensions:	Max. Overall Length	2-5/8 ins.
	Max. Diameter	3/4 in.
	Max. Seated Height	2-3/8 ins.

Base: B.V.A. Standard Base Type B7G

Basing Connections:

Pin 1 No Connection
Pin 2 No Connection
Pin 3 Heater
Pin 4 Heater
Pin 5 Anode
Pin 6 Heater Tap
Pin 7 Cathode

Dial lamp heater section between pins 4 and 6.

Ratings:

Half-Wave Rectifier:

Max. Peak Inverse Voltage	700 volts
Max. Peak Anode Current	600 mA
With Condenser Input Filter:	
Max. AC Anode Voltage (R.M.S.)	250 volts*
Min. Effective Limiting Resistance	120 ohms
Max. Reservoir Condenser	32 mfd.
Max. DC Output Current without Dial Lamp	100 mA
With Dial Lamp only	60 mA
With Dial Lamp and Resistor	90 mA

* Ratings above 117 volts R.M.S. input may not be applicable to 35W4's of other manufacturers.

CHARACTERISTIC CURVES: Curves taken with no dial lamp are attached to this report which show:

Anode current plotted against anode voltage I_a/V_a (Curve No. 301·42).

DC output voltage plotted against DC load current for an AC R.M.S. input of 117 volts and various values of reservoir condenser (Curve No. 301·34).

DC output voltage plotted against DC load current for an input of 250 volts R.M.S. for various values of reservoir condenser (Curve No. 301·43).

DC output voltage plotted against DC load current for various R.M.S. input voltages and a reservoir condensor of 32 mfd (Curve No. 301·44).

TYPICAL OPERATION

Half-Wave Rectifier (without dial lamp):

Heater Current	0·15		0·15		ampere
AC Anode Voltage R.M.S.	250		117		volts
Limiting Resistance*	100		15		ohms
Reservoir Condenser	16		16		mfd
Output Current (DC)	75	100	75	100	mA
Output Voltage (DC)	245	225	115	103	volts

Half-Wave Rectifier (with dial lamp):

Heater current	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	amperes
AC Anode Voltage R.M.S.	117	117	117	117	250	250	250	250	volts
Limiting Resistor*	15	15	15	15	100	100	100	100	Ω
Panel Lamp Shunting Resistor	—	300	150	100	—	300	150	100	Ω
DC Output Current	60	70	80	90	60	70	80	90	

* The value of the limiting resistances shown above are minimum values; these resistances are necessary in order to limit the peak anode current of the figure given on page 2. They may be omitted in the form of an actual resistance where at least the value given is included in the mains dropping resistance or line cord between the anode and the live mains connection. In the case of 250 volts operation the resistance should be of the 1 watt type and preferably be of a type that will not catch fire when over run in the event of a short circuit in the HT supply of the equipment: a vitreous wire wound type is recommended.

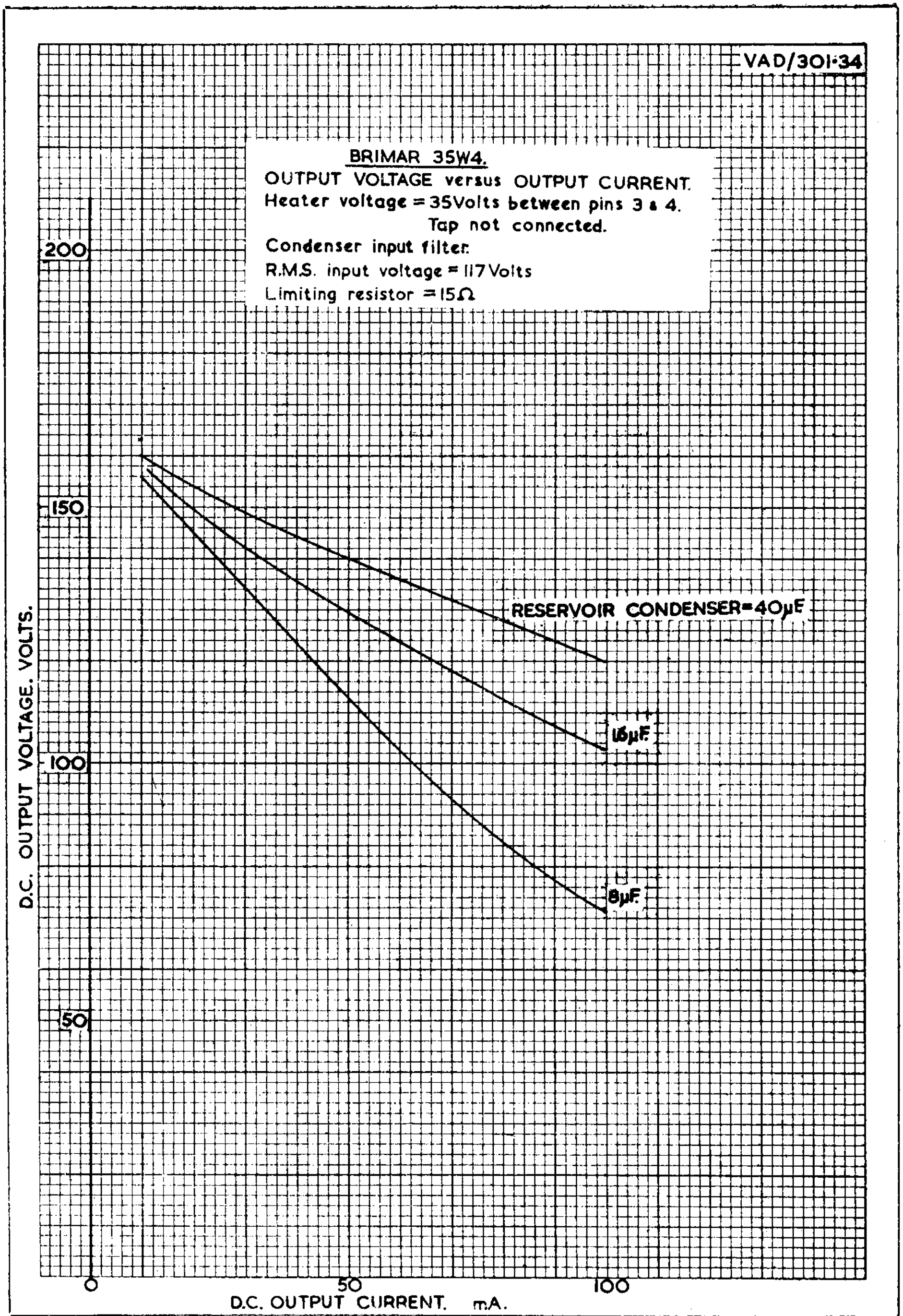
Recommendations for Operation with Dial Lamp: The valve is designed for use with a dial lamp rated at 6·3 volts 0·15 ampere and if the rectified DC load exceeds 60 mA an additional shunting resistor across the lamp and pins 4 and 6 is essential with values as follows:

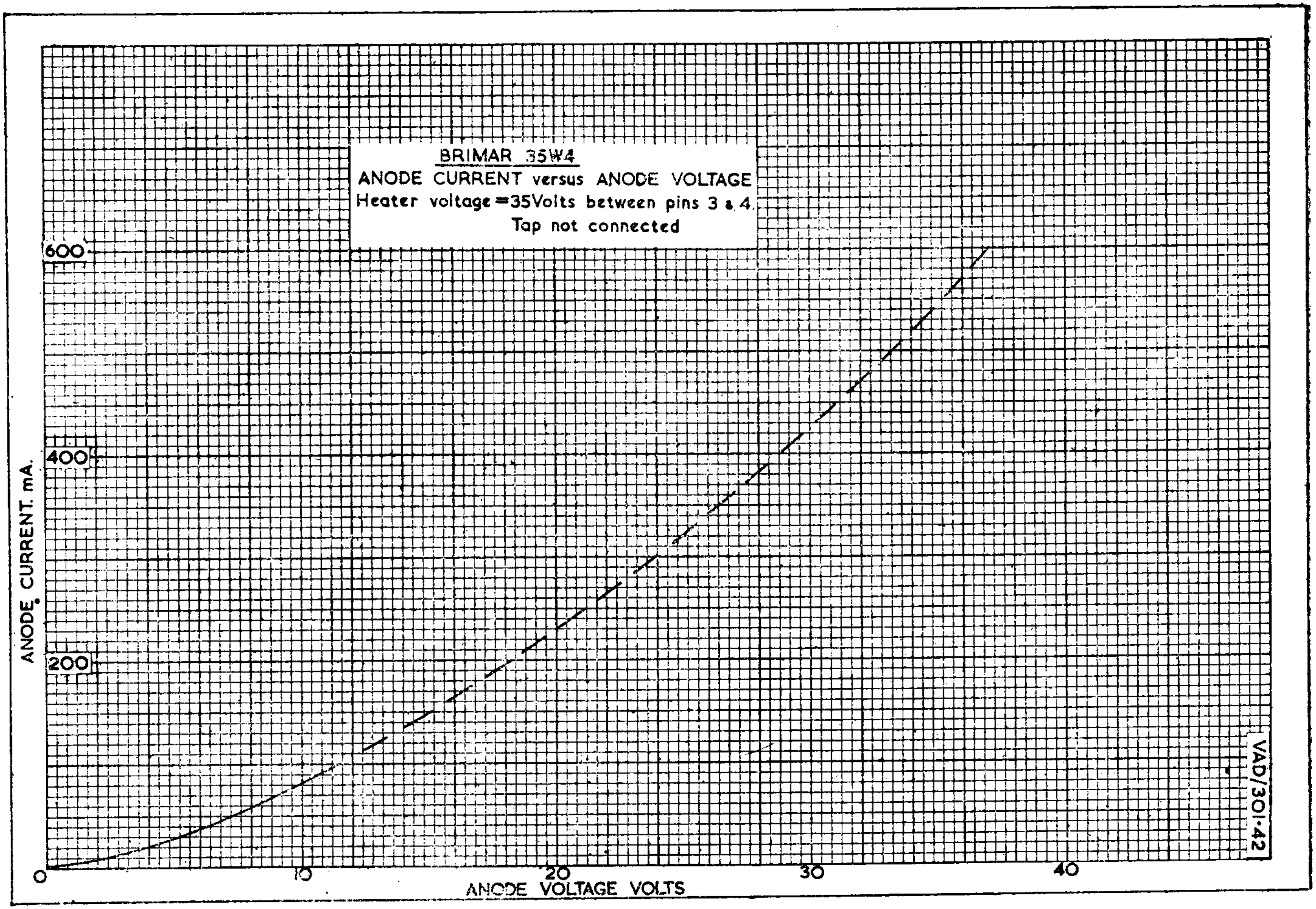
70 mA	800 ohms max.
80 mA	400 ohms max.
90 mA	250 ohms max.

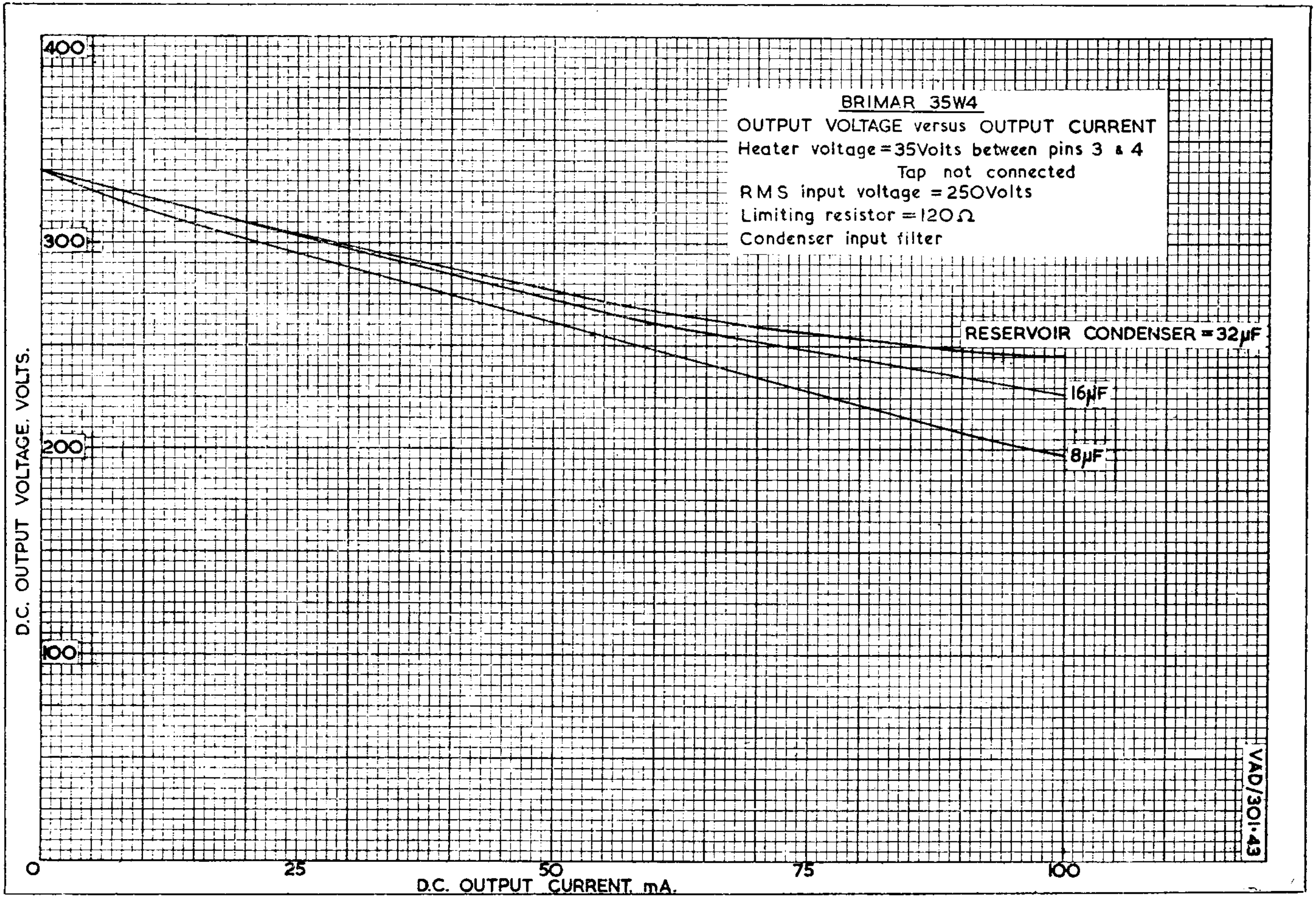
A typical circuit (Ref. VAD/301·51) showing the connections for a dial lamp and shunting resistor is attached to this report.

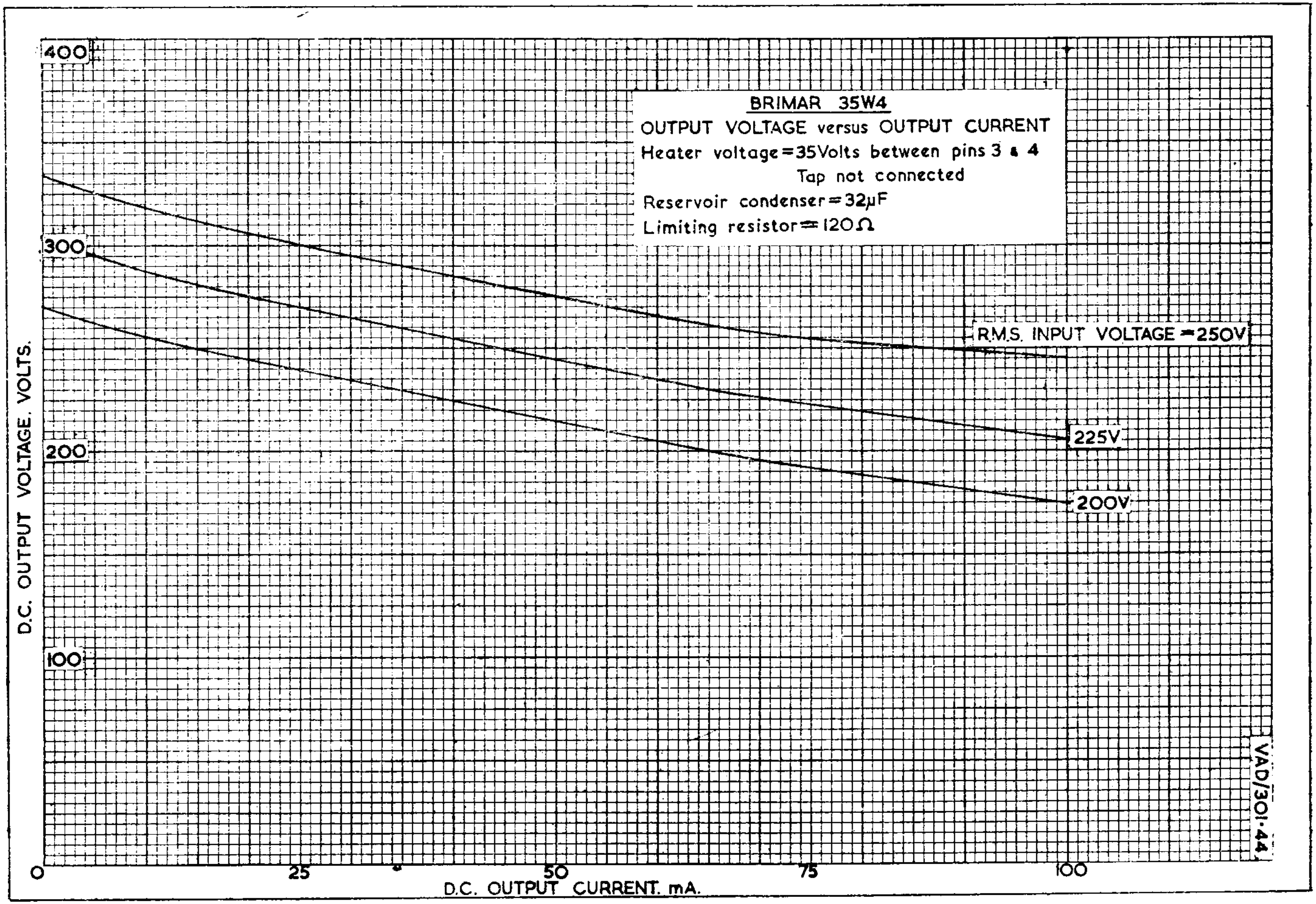
WARNING. Where the supply of the correct rating lamp cannot be ensured for replacement purposes and there is any danger that the lamp may be replaced with one of different current rating, the valve should not be operated at DC output ratings above 60 mA, with the circuit shown, or there will be a danger of the section of the heater, between pins 4 and 6, being either under or over run.

It is, therefore, recommended that in general the valve should be employed in a conventional manner, the dial lamp being in series with the other heaters and protected with suitable Brimistors, rather than reliance being placed on the supply of suitable lamps.


VAD/301-34
BRIMAR 35W4.
OUTPUT VOLTAGE versus OUTPUT CURRENT.
Heater voltage = 35Volts between pins 3 & 4.
Tap not connected.
Condenser input filter.
R.M.S. input voltage = 117 Volts
Limiting resistor = 15Ω
RESERVOIR CONDENSER=40μF
16μF
8μF
200
150
100
50
0
50
100
D.C. OUTPUT VOLTAGE. VOLTS.
D.C. OUTPUT CURRENT. mA.

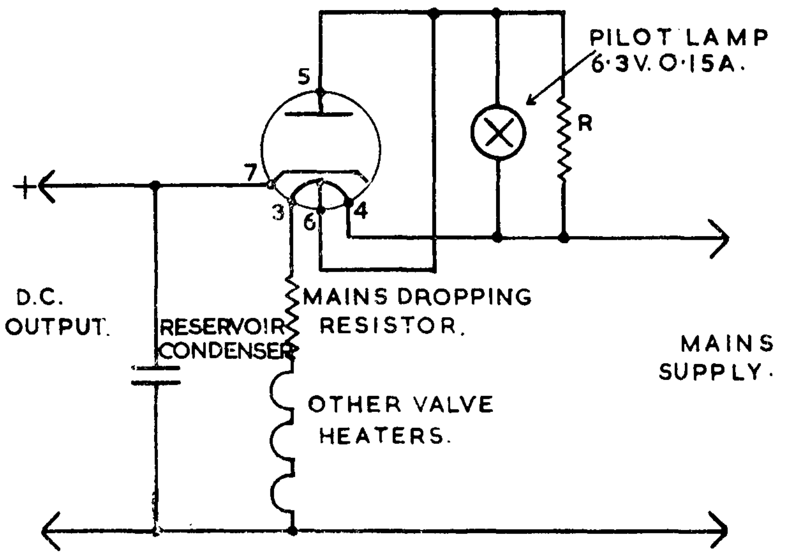

BRIMAR 35W4
ANODE CURRENT versus ANODE VOLTAGE
Heater voltage = 35Volts between pins 3 & 4
Tap not connected
600
400
200
0
ANODE CURRENT. mA.
10
20
30
40
ANODE VOLTAGE VOLTS
VAD/301·42


BRIMAR 35W4
OUTPUT VOLTAGE versus OUTPUT CURRENT
Heater voltage = 35Volts between pins 3 & 4
Tap not connected
RMS input voltage = 250Volts
Limiting resistor = 120Ω
Condenser input filter
RESERVOIR CONDENSER = 32μF
16μF
8μF
VAD/301·43
400
300
200
100
0
25
50
75
100
D.C. OUTPUT VOLTAGE. VOLTS.
D.C. OUTPUT CURRENT. mA.


BRIMAR 35W4
OUTPUT VOLTAGE versus OUTPUT CURRENT
Heater voltage = 35 Volts between pins 3 & 4
Tap not connected
Reservoir condenser = 32μF
Limiting resistor = 120Ω
R.M.S. INPUT VOLTAGE = 250V
225V
200V
400
300
200
100
0
25
50
75
100
D.C. OUTPUT VOLTAGE. VOLTS.
D.C. OUTPUT CURRENT. mA.
VAD/301·44

BRIMAR 35W4

CIRCUIT FOR UTILISING PILOT LAMP TAP



OUTPUT CURRENT mA.	PILOT LAMP SHUNT(R) OHMS *
60 & BELOW	NOT REQUIRED.
70	800
80	400
90	250

* SEE ALSO PAGE 3

BRIMAR

RECEIVING VALVE

50C5

APPLICATION REPORT VAD/507.7

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

Issued March, 1950. Reprinted January, 1952.

INTRODUCTION: The Brimar valve type 5OC5 is a miniature indirectly heated beam tetrode. The heater is of the 150 milliamp type and is intended for operation in series with other valves having a similar heater current, such as in AC/DC equipment. The valve is suitable for use only on 110 volt mains or in equipment employing an HT line voltage not exceeding 140 volts.

DESCRIPTION: The valve consists of a beam tetrode unit capable of an output of the order of 2 watts. The unit is mounted in a standard T5½ bulb and is based with a B.V.A. Standard type B7G base.

This report contains characteristics of the valve and details of its use as a tetrode in push-pull or single ended amplifiers, and as a triode in push-pull or single ended amplifiers.

CHARACTERISTICS:

Cathode:	Indirectly heated	
	Voltage (nominal)	50 volts
	Current	0·15 ampere*
	Max. DC Heater Cathode potential	180 volts

* The heater current should not vary more than 5% from the rated value at any time, particularly is this important if the valve is used near its maximum ratings.

Dimensions:	Max. Overall Length	2-5/8 ins.
	Max. Diameter	3/4 in.
	Max. Seated Height	2-3/8 ins.
Base:	Type B7G	
Basing Connections:	Pin 1 Cathode and g_3	
	Pin 2 Control Grid g_1	
	Pin 3 Heater	
	Pin 4 Heater	
	Pin 5 Control Grid g_1	
	Pin 6 Screen g_2	
	Pin 7 Anode	
Ratings:	Max. Anode Voltage	135 volts
	Max. Screen Voltage	117 volts
	Max. Anode Dissipation	5·5 watts
	Max. Screen Dissipation	1·25 watts
Capacities (approx.) †	$c_{g, a}$	0·64 pF
	c Input (c_{in})	13 pF
	c Output (c_{out})	6·1 pF
	$c_{h, k}$	17 pF

† Measured without shield.

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

Anode current plotted against anode volts for various values of grid voltage for the valve connected as a tetrode (I_a/V_a) (Curve No. 307·261).

Anode current plotted against anode volts for various values of grid voltage for the valve connected as a triode (I_a/V_a) (Curve No. 307·262).

TYPICAL OPERATION

Class A1 Amplifier (single ended):

Heater Current	0·15 ampere
Anode Voltage	110 volts
Screen Voltage	110 volts
Grid Voltage	—7·5 volts
Autobias Resistance	140 ohms
Anode Current	49 mA
Screen Current	4 mA approx.
Anode Impedance (r_a)	10,000 ohms
Mutual Conductance	7·5 mA/V
Inner Amplification Factor (μ)	5
Anode Load Resistance	2500 ohms
Peak AF Grid Voltage	7·5 volts
Total Harmonic Distortion	9%
Power Output	1·9 watts

A curve is attached to this report which shows the relation between power output, distortion and input signal voltage (Curve No. 307·263).

Class A1 Amplifier Push-Pull:

Heater Current	0·15 ampere
Anode Voltage	110 volts
Screen Voltage	110 volts
Grid Voltage	—7·5 volts
Autobias Resistance	70 ohms
Anode Current	98 mA
Screen Current	8 mA approx.
Output Load (anode-anode)	4000 ohms
Peak AF Grid Voltage (grid-grid)	15 volts
Total Harmonic Distortion	7%
Power Output	3·75 watts

Note.—Values given are for two valves.

A curve is attached to this report which shows the relation between power output, harmonic distortion, and input signal voltage (Curve No. 307·264).

Class A1 Amplifier (Triode connected) (single ended):

Heater Current	0·15 ampere
Max. Anode and Screen Dissipation (total)	6·75 watts
Max. Anode Voltage	110 volts
Grid Voltage	—7·5 volts
Autobias Resistance	140 ohms
Anode Current	53 mA
Anode Impedance (r_a)	850 ohms
Mutual Conductance	8·2 mA/V
Amplification Factor (μ)	7
Load Resistance	1000 ohms
Harmonic Distortion	4·8%
Max. Power Output	350 milliwatts

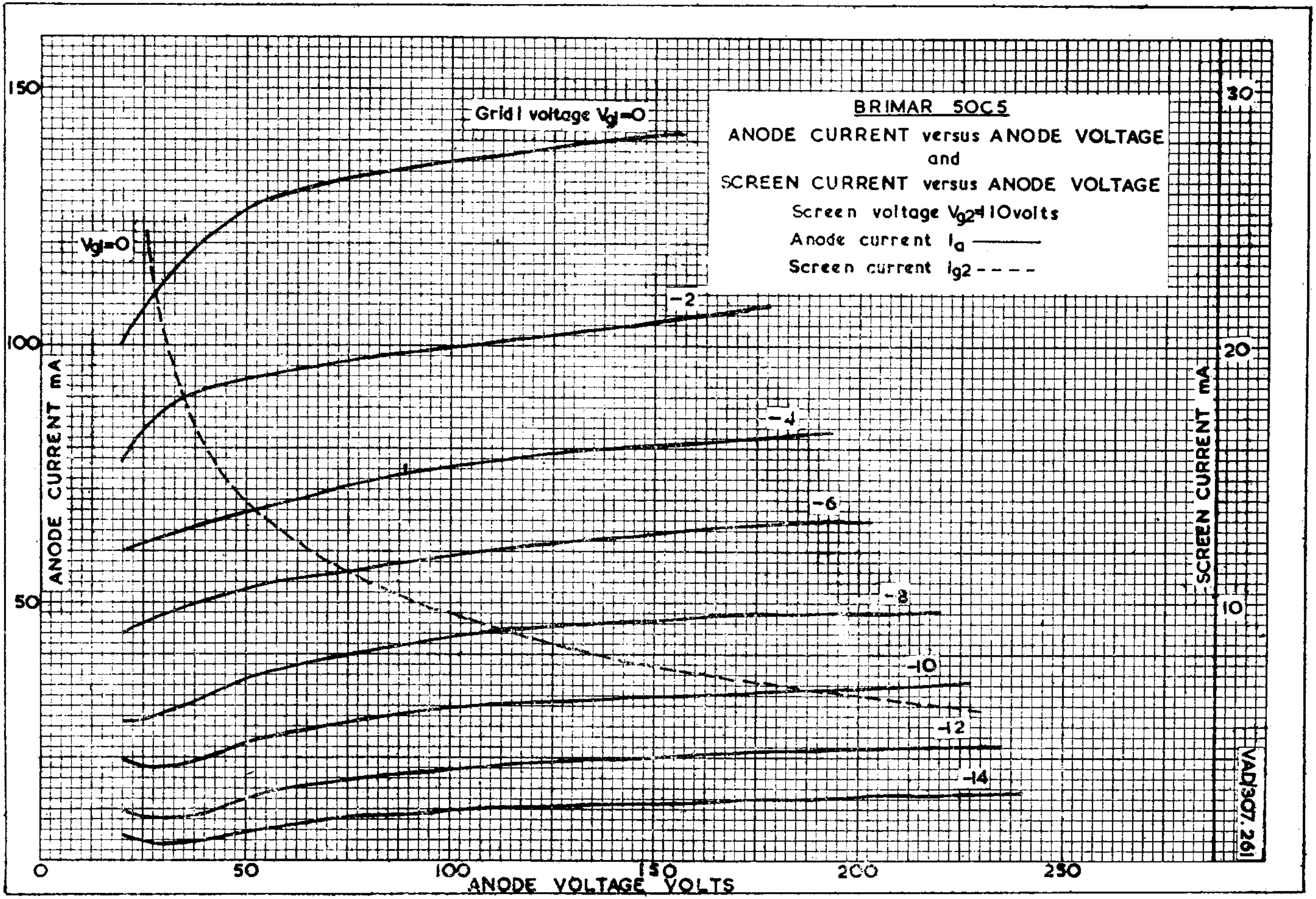
A curve is attached to this report showing the relation between power output, harmonic distortion, and signal input voltage (Curve No. 307·265).

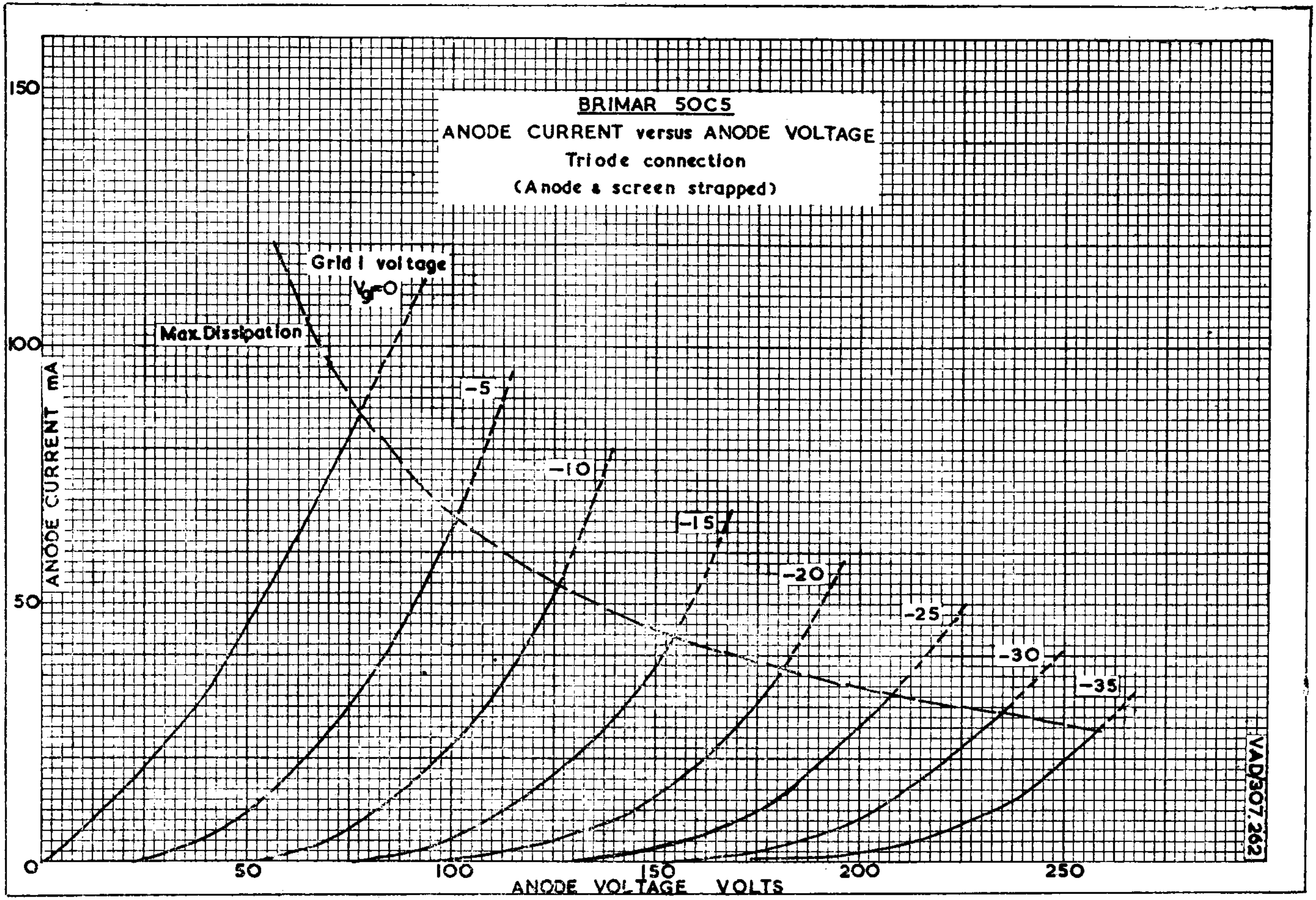
Class A1 Amplifier (Triode connected) (Push-Pull):

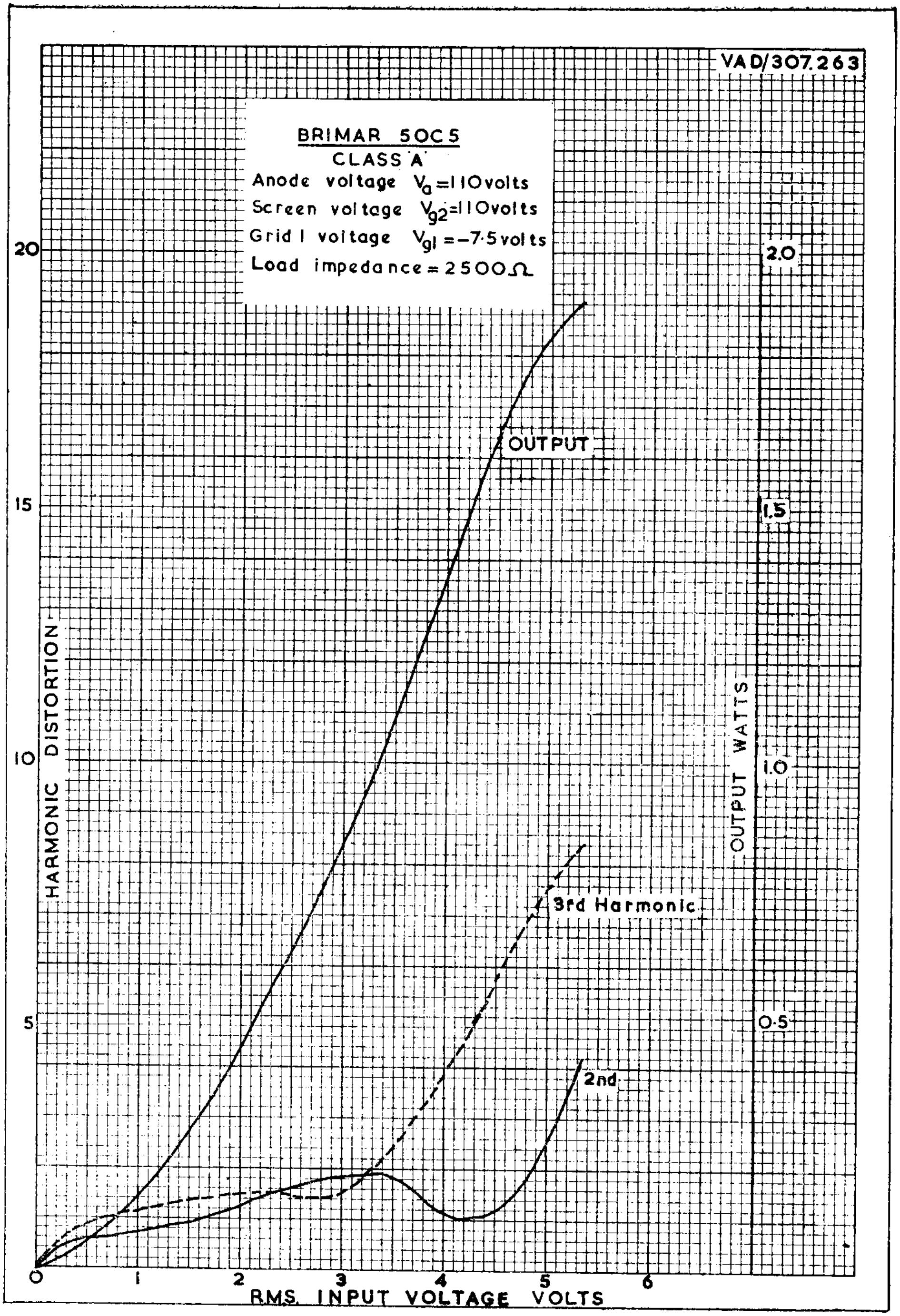
Heater Current	0·15 ampere
Anode Voltage	110 volts
Grid Voltage	—7·5 volts
Autobias Resistance	70 ohms
Anode Current	106 mA
Output Load (anode-anode)	2000 ohms
Peak AF Grid Voltage (grid-grid)	15 volts
Total Harmonic Distortion	2·1%
Power Output	0·75 watts

Note.—Values given are for two valves.

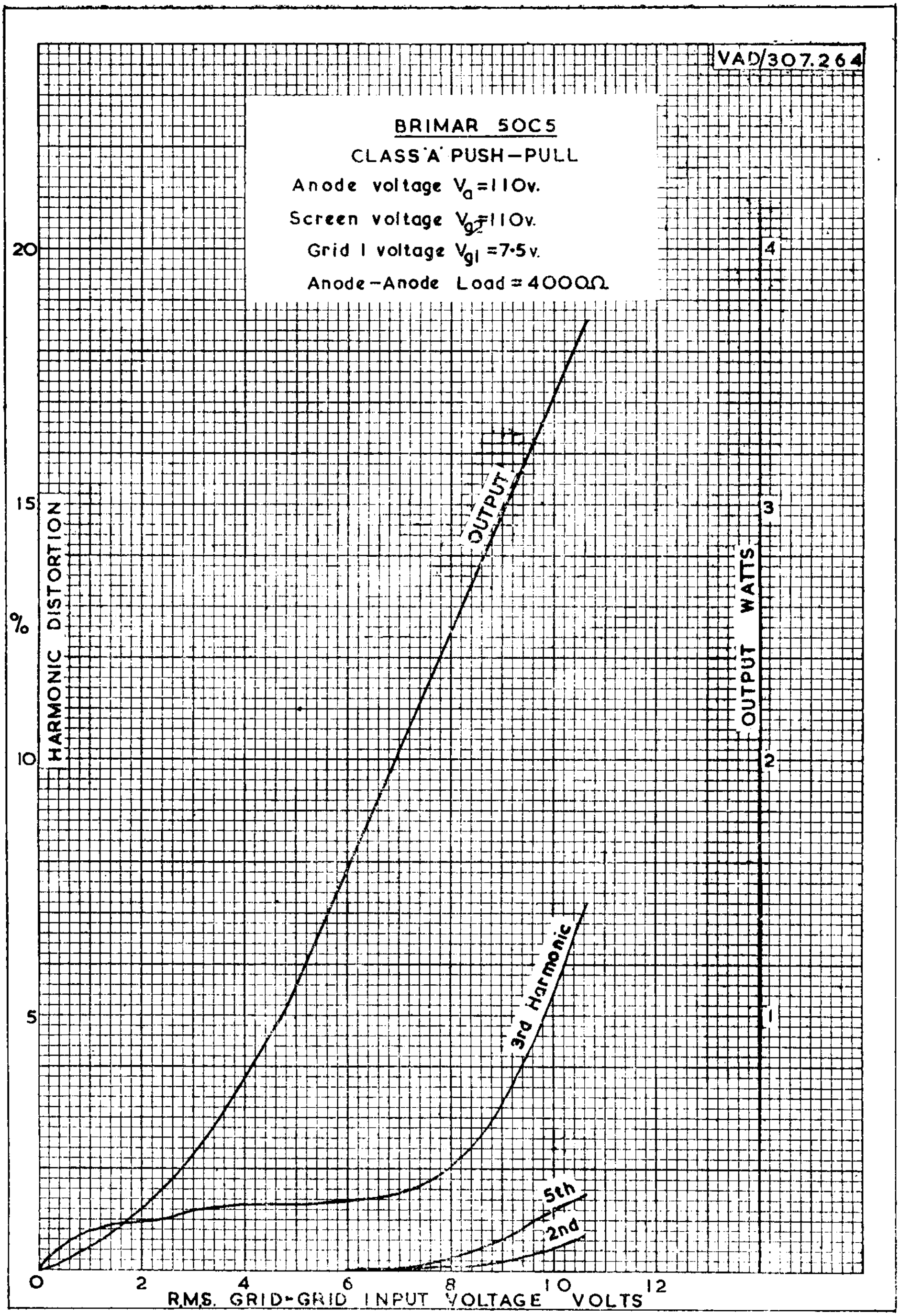
Curves are attached to this report which show the relation between power output, harmonic distortion, and input signal voltage (Curve No. 307·266).


BRIMAR 50C5
ANODE CURRENT versus ANODE VOLTAGE
and
SCREEN CURRENT versus ANODE VOLTAGE
Screen voltage Vg2=110volts
Anode current Ia ————
Screen current Ig2 - - - -
Grid1 voltage Vg1=0
Vg1=0
-2
-4
-6
-8
-10
-12
-14
ANODE CURRENT mA
SCREEN CURRENT mA
ANODE VOLTAGE VOLTS
0
50
100
150
200
250
10
20
30
VAD/307.261

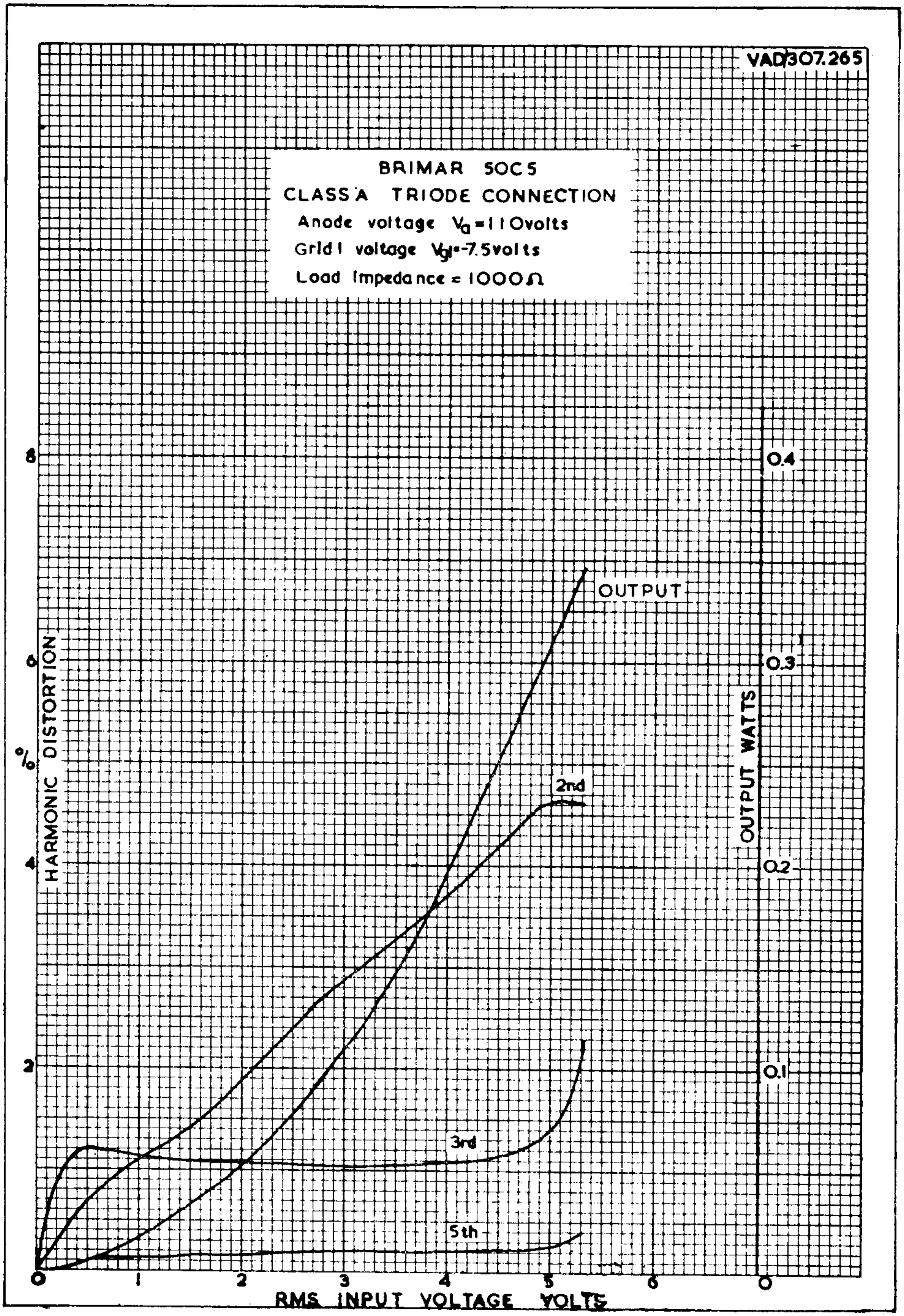

BRIMAR 50C5
ANODE CURRENT versus ANODE VOLTAGE
Triode connection
(Anode & screen strapped)
Grid I voltage
V_g=0
Max. Dissipation
-5
-10
-15
-20
-25
-30
-35
ANODE CURRENT mA
150
100
50
0
50
100
150
200
250
ANODE VOLTAGE VOLTS
VAD/307.262



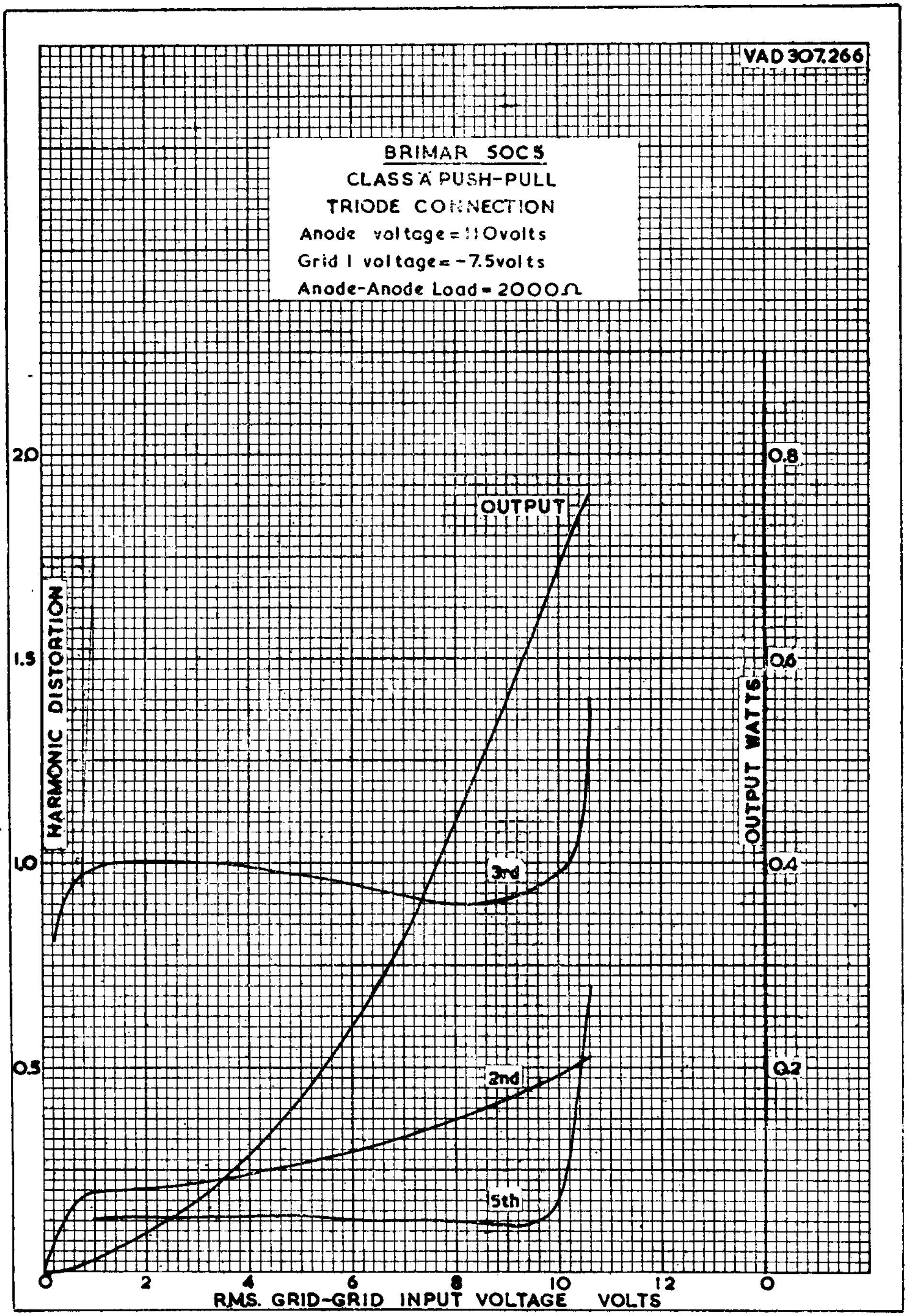
VAD/307.263
BRIMAR 50C5
CLASS 'A'
Anode voltage V_a = 110 volts
Screen voltage V_{g2} = 110 volts
Grid 1 voltage V_{g1} = −7·5 volts
Load impedance = 2500Ω
OUTPUT
3rd Harmonic
2nd
HARMONIC DISTORTION
OUTPUT WATTS
R.M.S. INPUT VOLTAGE VOLTS
0
1
2
3
4
5
6
5
10
15
20
0·5
1.0
1.5
2.0



VAD/307.264
BRIMAR 50C5
CLASS 'A' PUSH-PULL
Anode voltage V_a=110v.
Screen voltage V_{g2}=110v.
Grid 1 voltage V_{g1}=7·5v.
Anode-Anode Load=4000Ω.
OUTPUT
3rd Harmonic
5th
2nd
% HARMONIC DISTORTION
OUTPUT WATTS
R.M.S. GRID-GRID INPUT VOLTAGE VOLTS
0
2
4
6
8
10
12
5
15
20
1
2
3
4



VAD307.265
BRIMAR 50C5
CLASS A TRIODE CONNECTION
Anode voltage Va = 110volts
Grid 1 voltage Vg1 = -7.5volts
Load Impedance = 1000Ω
OUTPUT
2nd
3rd
5th
% HARMONIC DISTORTION
OUTPUT WATTS
RMS INPUT VOLTAGE VOLTS
0
1
2
3
4
5
6
2
4
6
8
0.1
0.2
0.3
0.4



VAD 307.266
BRIMAR 50C5
CLASS A PUSH-PULL
TRIODE CONNECTION
Anode voltage = 110 volts
Grid 1 voltage = -7.5 volts
Anode-Anode Load = 2000Ω
OUTPUT
3rd
2nd
5th
HARMONIC DISTORTION
OUTPUT WATTS
2.0
1.5
1.0
0.5
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
0
RMS. GRID-GRID INPUT VOLTAGE VOLTS

BRIMAR

RECEIVING VALVE

5763

APPLICATION REPORT VAD/507.6

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

Issued October, 1949. Reprinted January, 1952.

INTRODUCTION: The Brimar valve type 5763 is a miniature indirectly heated screened beam tetrode. The heater is intended for operation in parallel with other valves in AC operated equipment. The valve is primarily designed for use as an RF amplifier or frequency multiplier in VHF transmitters, but may, where suitable, be employed as an AF amplifier for modulation purposes.

DESCRIPTION: The valve consists of a beam tetrode unit capable of an output of the order of 8 watts. The unit is mounted in a standard T6½ bulb and is based with a BVA Standard B9A base.

CHARACTERISTICS:

Cathode:	Indirectly heated	
	Voltage (AC or DC)	6·0 volts*
	Current (nominal)	0·75 ampere
	Max. Heater Cathode potential (DC)	100 volts

* The voltage should not vary more than ±10% from the rated value.

Dimensions:	Max. Overall Length	2-5/8 ins.
	Max. Diameter	7/8 in.
	Max. Seated Height	2-3/8 ins.
Base:	Noval 9 pin Button B9A	
Basing Connections:	Pin 1 Anode	
	Pin 2 No connection	
	Pin 3 Grid 3	
	Pin 4 Heater	
	Pin 5 Heater	
	Pin 6 Grid 2	
	Pin 7 Cathode	
	Pin 8 Grid 1	
	Pin 9 Grid 1	

Ratings (Absolute Values):

(a) TETRODE CONNECTIONS:

Max. Anode Voltage	300††
Max. Screen Voltage	250††
Max. Anode Dissipation (watts)	12††
Max. Screen Dissipation (watts)	2††
Max. g_1 Circuit Resistance	100,000 ohms††
Max. Bulb Temperature (degrees C)	250††

(b) TRIODE CONNECTIONS:†

Max. (anode and screen strapped) Voltage	250 volts††
Max. (anode and screen strapped) Dissipation	12 watts††

† In order to avoid parasitic oscillation pins 1 and 6 should be connected together through a 100 ohm resistance or an RF choke about 20 microhenries.

†† These ratings are absolute and must be reduced under certain specified conditions referred to later in this report.

Frequency Ratings: The ratings given above in paragraphs (a) and (b) apply to frequencies up to 175 Mc/s. Above this frequency the maximum anode voltage and anode dissipation must be reduced. Data as to the requisite reduction is not yet available.

Capacities (approx.):

$c_{g,a}$	0·3 pF (max.)*
c Input (c_{in})	9·5 pF (max.)*
c Output (c_{out})	4·5 pF (max.)*
$c_{h,k}$	7·0 pF (max.)*

* With no external shielding.

Mounting: The valve may be mounted in any position.

Ventilation: As this valve runs very hot in operation the layout and design of equipment should be such that adequate ventilation is afforded to ensure a safe bulb temperature under all conditions. The bulb temperature at the hottest point in the bulb surface should never exceed 250° C.

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

Anode current plotted against anode voltage for various values of grid voltage for the valve connected as a tetrode with a screen voltage of 250 volts (I_a/V_a) (Curve No. 307·239).

Anode current plotted against anode voltage for various values of grid voltage for the valve connected as a tetrode with a screen voltage of 225 volts (I_a/V_a) (Curve No. 307·240).

Anode current plotted against anode voltage for various values of grid voltage for the valve connected as a triode (I_a/V_a) (Curve No. 307·241).

TYPICAL OPERATION (Audio Frequencies)

Class A Amplifier (Single Ended):

TRIODE CONNECTION (Pins 1 and 6 Strapped):

Heater Voltage	6·0 volts
Anode Voltage	250 volts
Grid Voltage	—7·5 volts
Autobias Resistor (R_k)	150 ohms
Anode Current (no signal)	50 mA
Anode Impedance (r_a)	2100 ohms
Amplification Factor (μ)	15·75
Mutual Conductance	7·5 mA/V
Anode Load Resistor (R_a)	4000 ohms
Peak AF Grid Voltage	7·1 volts
Total Harmonic Distortion	5·2%
Power Output	0·7 watts

A curve (No. 307·254) shows the relation between power output, distortion and input signal voltage.

Class A Amplifier Push-Pull:

TRIODE CONNECTED (Pins 1 and 6 Strapped):

Heater Voltage	6·0 volts
Anode Voltage	250 volts
Grid Voltage	—7·25 volts
Autobias Resistor (R_k)	75 ohms
Anode Current (no signal)	98 mA
Output Load (anode-anode) (R_a)	5000 ohms
Peak AF Grid Voltage (grid-grid)	29·4 volts
Total Harmonic Distortion	1·6%
Power Output	1·7 watts

Note.—Values given are for two valves.

A curve (No. 307·255) shows the relation between power output, distortion and input signal voltage.

Class A Amplifier (Single Ended):

TETRODE CONNECTION:

Heater Voltage	6·0	6·0	6·0	6·0	volts
Anode Voltage	250	250	300	300	volts
Screen Voltage	225	225	225	225	volts*
Grid Voltage	—6·25	—	—7·4	—	volts
Autobias Resistor	—	120	—	175	ohms
Anode Current	45	45	40	40	mA
Screen Current	3·7	3·9	2·3	2·4	mA
Anode Impedance (r_a)	38000	—	65000	—	ohms
Mutual Conductance	6·8	—	6·3	—	mA/V
Anode Load Resistance	5500	5500	8500	8500	ohms
Peak AF Grid Voltage	6·1	6·2	6·8	7·3	volts
Harmonic Distortion Total	5·1	5·6	7·0	7·6	%
Power Output	2·85	2·8	4·0	4·15	watts

* The screen voltage, where lower than the anode voltage, should be obtained from a potentiometer across the HT line to chassis adequately by-passed to AF signals, and not by means of a series resistance.

Curves are attached to this report which show the relation between power output, distortion and input signal voltage. Curve No. 307·242 at anode volts 250, screen volts 225 and fixed bias, Curve No. 307·243 for autobias. Similarly curves Nos. 307·244 and 307·245 for an anode voltage of 300 volts.

Class A Amplifier (Push-Pull):

TETRODE CONNECTION:

Heater Voltage	6·0	6·0	6·0	volts
Anode Voltage	250	250	300	volts
Screen Voltage	225	225	225	volts
Grid Voltage	—6·25	—	—	volts
Autobias Resistor	—	68	68	ohms
Peak AF (grid-grid) Voltage	12·5	14	13·75	volts
No Signal Anode Current	88	84	86·5	mA
Max. Signal Anode Current	89	84·5	85	mA
No Signal Screen Current	7·2	6·9	5·6	mA
Max. Signal Screen Current	18	18	14·6	mA
Load Resistance (anode-anode)	11500	11500	11500	ohms
Total Harmonic Distortion	3·9	4·2	4·2	%
Power Output	6·2	6·7	7·5	watts

Note.—Values given are for two valves.

Curves are attached to this report showing the relation between power output, distortion and input signal voltage. Curve No. 307·246 at anode volts 250, screen volts 225, and fixed bias and curve No. 307·247 for autobias. Curve No. 307·248 shows the performance at anode volts 300.

Class AB1 Amplifier (Push-Pull):

TETRODE CONNECTION:

Heater Voltage	6·0	6·0	6·0	6·0	volts
Anode Voltage	250	250	300	300	volts
Screen Voltage	225	225	225	225	volts
Grid Voltage	—9	—	—9	—	volts
Autobias Resistor	—	150	—	150	ohms
Peak AF (grid-grid) Voltage	18	21·5	18·5	21	volts
No Signal Anode Current	58	56	59	57	mA
Max. Signal Anode Current	67	56	70	57	mA
No Signal Screen Current	3·8	3·7	3·0	2·8	mA
Max. Signal Screen Current	18	16·4	17·2	14·5	mA
Load Resistance (anode-anode)	11500	11500	13500	13500	ohms
Total Harmonic Distortion	4·2	3·5	5·1	4·4	%
Power Output	7·8	7·2	9·8	8·8	watts

Note.—Values given are for two valves.

Curves are attached to this report which show the relation between power output, distortion and input signal voltage for the above conditions. Curves Nos. 307·249 and 307·250 for an anode voltage of 250 volts, and fixed and autobias respectively. Curves Nos. 307·251 and 307·252 for an anode voltage of 300 volts and fixed and autobias respectively.

Class AB2 Amplifier (Push-Pull):

TETRODE CONNECTION:

Heater Voltage	6·0 volts
Anode Voltage	300 volts
Screen Voltage	225 volts
Grid Voltage	—12·5 volts
Peak AF (grid-grid) Voltage	71 volts
No Signal Anode Current	27 mA
Max. Signal Anode Current	140 mA
No Signal Screen Current	1·2 mA
Max. Signal Screen Current	18 mA
Peak Grid Input Power	0·8 watts
Load Resistance (anode-anode)	4500 ohms
Total Harmonic Distortion	9·6 %
Power Output	25 watts

Note.—Values given are for two valves.

It is essential for Class AB2 operation that the regulation of the anode and screen supplies is such that the voltages remain constant within 5% and that of the grid bias within 3% between no signal and maximum signal conditions.

The driver stage should be capable of supplying the grids of the two valves with the specified peak voltages with low distortion. The effective resistance per grid circuit presented by the driver valve and/or transformer should not exceed 500 ohms and the effective impedance represented by leakage inductance or equivalent at the highest desired response frequency should not exceed 700 ohms.

Curve No. 307·253 attached to this report shows the relation between power output, distortion and input signal voltages for the above conditions.

General Recommendations—Audio Frequencies: Due to the relatively high slope of this valve, it is prone to parasitic oscillation and it is advised that a resistance of 100 ohms is always wired in series with the anode directly connected to the valve holder anode contact; this resistance should be reduced to 47 ohms in the case of Class AB2 operation. A series grid resistance may also be employed, if necessary, wired directly to the valve holder grid contact, but the value must be carefully chosen bearing in mind the frequency response. Such resistance should never exceed 100,000 ohms for Class A operation and should not be employed for Class AB2 operation.

The type of input coupling used should not introduce too much resistance into the grid circuit. It is essential that such resistance does not exceed 100,000 ohms.

TYPICAL OPERATION (Radio Frequencies)

RF POWER AMPLIFIER AND OSCILLATOR:

Class C Telegraphy or Class C FM Telephony

Maximum Continuous Ratings (Absolute Values)

D.C. Anode Voltage (max.)	300 volts
D.C. Grid 3 Voltage (max.)	0 volts
D.C. Grid 2 Voltage (max.)	250 volts
D.C. Grid 1 Voltage (max.)	—125 volts
D.C. Anode Current (max.)	50 mA
D.C. Grid 2 Current (max.)	15 mA
D.C. Grid 1 Current (max.)	5 mA
D.C. Anode Input (max.)	15 watts
D.C. Anode Dissipation (max.)	12 watts
D.C. Grid 2 Input (max.)	2 watts
Bulb Temperature at hottest point on the surface (max.)	250° C.

Typical Operation at 50 Mc/s:

D.C. Anode Voltage	300 volts
D.C. Grid 2 Voltage	250 volts
D.C. Grid 1 Voltage	—60 volts
D.C. Grid 1 Resistor	22,000 ohms
Peak RF Grid Voltage	80 volts
D.C. Anode Current	50 mA
D.C. Grid 2 Current	5 mA
D.C. Grid 1 Current (approx.)	3 mA
Driving Power (approx.)	0·35 watts
Power Output (neglecting output tuned circuit loss)	8 watts

FREQUENCY MULTIPLIER:

Maximum Continuous Ratings (Absolute Values)

Without Modulation:

D.C. Anode Voltage (max.)	300 volts
D.C. Grid 3 Voltage (max.)	0 volts
D.C. Grid 2 Voltage (max.)	250 volts
D.C. Grid 1 Voltage (max.)	—125 volts
D.C. Anode Current (max.)	50 mA
D.C. Grid 2 Current (max.)	15 mA
D.C. Grid 1 Current (max.)	5 mA
D.C. Anode Input	15 watts
D.C. Anode Dissipation	12 watts
D.C. Grid 2 Dissipation	2 watts
Bulb Temperature at hottest point on the surface (max.)	250° C.

Typical Operation:

	Doubler to 175 Mc/s	*Tripler to 175 Mc/s*	
D.C. Anode Voltage	300	300	volts
D.C. Grid 2 Supply Voltage	300	300	volts
Series Grid 2 Resistor	12,500	12,500	ohms
D.C. Grid 1 Voltage	—75	—100	volts
D.C. Grid 1 Resistor	75,000	100,000	ohms
Peak RF Grid 1 Voltage	95	120	volts
D.C. Anode Current	40	35	mA
D.C. Grid 2 Current	4	5	mA
D.C. Grid 1 Current (approx.)	1	1	mA
Driving Power (approx.)	0·6	0·6	watts
Power Output (neglecting output tuned circuit loss)	3·6	2·8	watts

TYPICAL CIRCUIT DATA

The circuit (Ref. 307·51) shows a typical arrangement of a master oscillator-power amplifier employing a 6C4 to drive a 5763 at 50 Mc/s. Employing the values as shown the measured power output is 7 watts with an anode current of 49 mA, screen current of 5 mA and a grid drive of 3·5 mA.

The circuit also shows the amendments when the 5763 is used as a frequency doubler to 100 Mc/s but in this case the output would be utilised to drive a succeeding stage and is, therefore, given in terms of available grid drive for a succeeding stage. As a frequency doubler the available DC drive at 100 Mc/s into an input of 15 pF and 25,000 ohms is 6 mA, with an anode current of 40 mA, screen current of 4 mA and grid drive of 1·4 mA.

Similarly amendments are shown when the 5763 is used as a frequency trebler to 150 Mc/s, and again the output is quoted in terms of available grid drive. As a frequency trebler the available DC drive at 150 Mc/s into an input of 10 pF and 25,000 ohms is 5 mA; with an anode current of 38 mA, screen current of 4·3 mA and grid drive of 1·8 mA.

GENERAL RECOMMENDATIONS (Radio Frequencies)

Due to the relatively high slope of this valve it is prone to parasitic oscillation and it is advised that when necessary a small resistor of 47 ohms or less is wired in series with the anode directly connected to the anode valve holder contact. The total effective grid circuit resistance at maximum conditions should not exceed 100,000 ohms and the DC grid current should at no time exceed 5 mA.

Attention is particularly drawn to the paragraph concerning frequency ratings on page 2. It is not recommended that it is used as a power amplifier at frequencies above 135 Mc/s because the input drive required increases due to the high frequency input loading; this of course does not apply as a frequency multiplier. Because of the relatively larger high frequency currents carried by the grid and anode contacts, heavy gauge conductors should be employed for wiring but these should be sufficiently flexible so as not to destroy the float of the contacts or misplace the contacts.

In order that the control grid does not run too hot it is essential that both No. 1 grid valve holder contacts (pins 8 and 9) are wired into the external circuit. When employed as an RF amplifier, neutralisation may not be necessary. If any screening is employed particular regard should be paid to ventilation, see page 3, and the shield should be matt black finished inside and out and have ventilation slots provided.

As a Class C amplifier bias may be obtained from a fixed supply or by grid rectification; in order to provide safety in the event of loss of drive, a minimum bias of —3 volts is adequate, and this value is furnished by a 68 ohm cathode resistor.

The grid driving power will depend on the anode load; if the anode load is relatively low the desired output can be obtained with relatively low grid current, but the efficiency will be lower; conversely if the anode load is high, the grid drive must be increased with correspondingly higher anode efficiency.

The highest efficiency will be obtained when the load conditions are such that the maximum rated anode current flows at the anode voltage which will give maximum rated input.

In order to allow of range of adjustment and provide for losses, more grid driving power should be available than is indicated in the data; particularly is this so towards the maximum frequency.

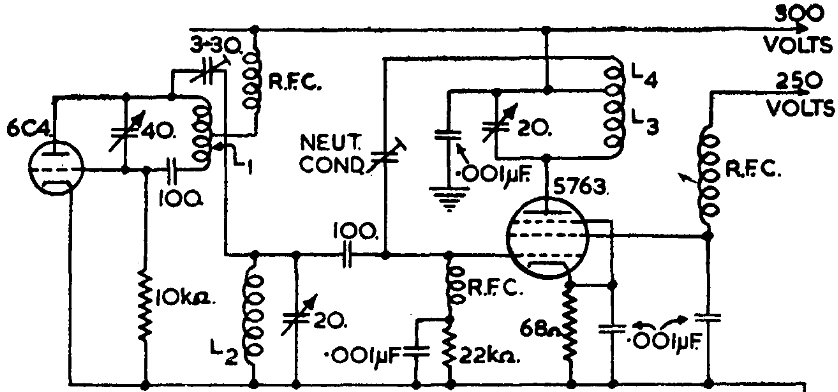
When more power is required than can be furnished by one valve, push pull or parallel arrangements may be used, but care should be exercised that the anode current drawn by each valve is the same.

When the valve is used in Aircraft Transmitters at high altitudes danger of flash over between the anode and suppressor grid g3 is reduced by the removal of the socket clip (pin 2) between the connection to pins 1 and 3 of the valve holder.

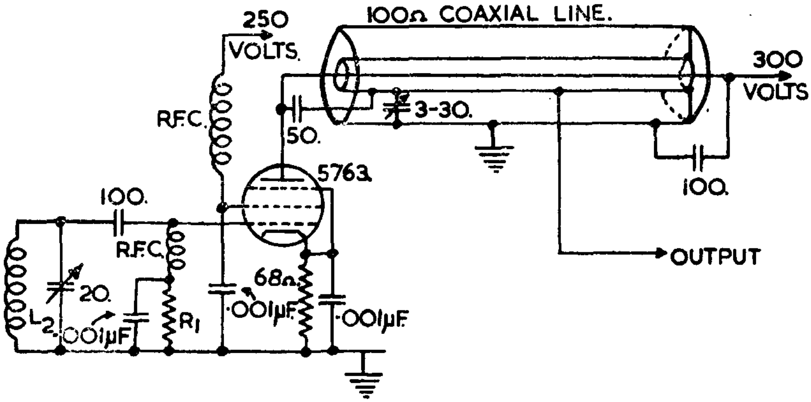
When used as an oscillator the heater to cathode insulation should not be across any part of the oscillator tuned circuit, as this will give rise to frequency drift and hum modulation. The valve may be used in an electron coupled oscillator circuit if the heater voltage is supplied via RF chokes, or via a winding interwound with the part of the coil associated with the cathode tap.

Cathode keying should not be employed unless a resistor not exceeding 0·25 megohms is permanently wired between heater and cathode. Keying by opening the screen circuit alone should not be employed since the anode current may not be completely cut off by disconnection of the screen. Further if the valve is operated near its maximum ratings there may be sufficient screen emission to maintain the screen voltage during the "key up" periods and prevent the use of "break-in" facilities. If it is necessary to interrupt the anode current by "open circuiting" the screen supply, the lowest practicable resistance should be permanently connected between the screen and cathode.

VAD/307.51



5763 AS AN R.F. POWER AMPLIFIER AT 50Mc/s.

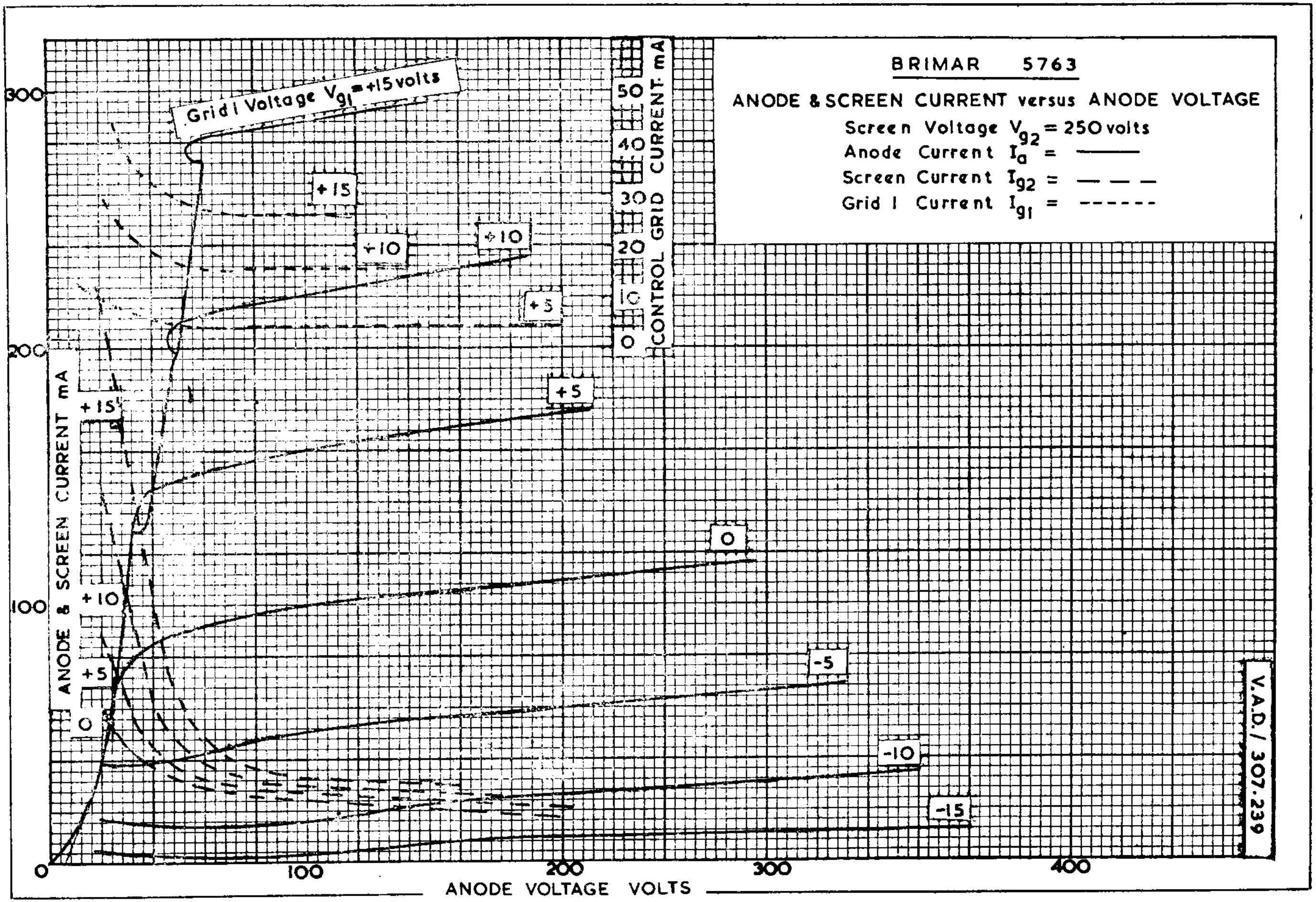


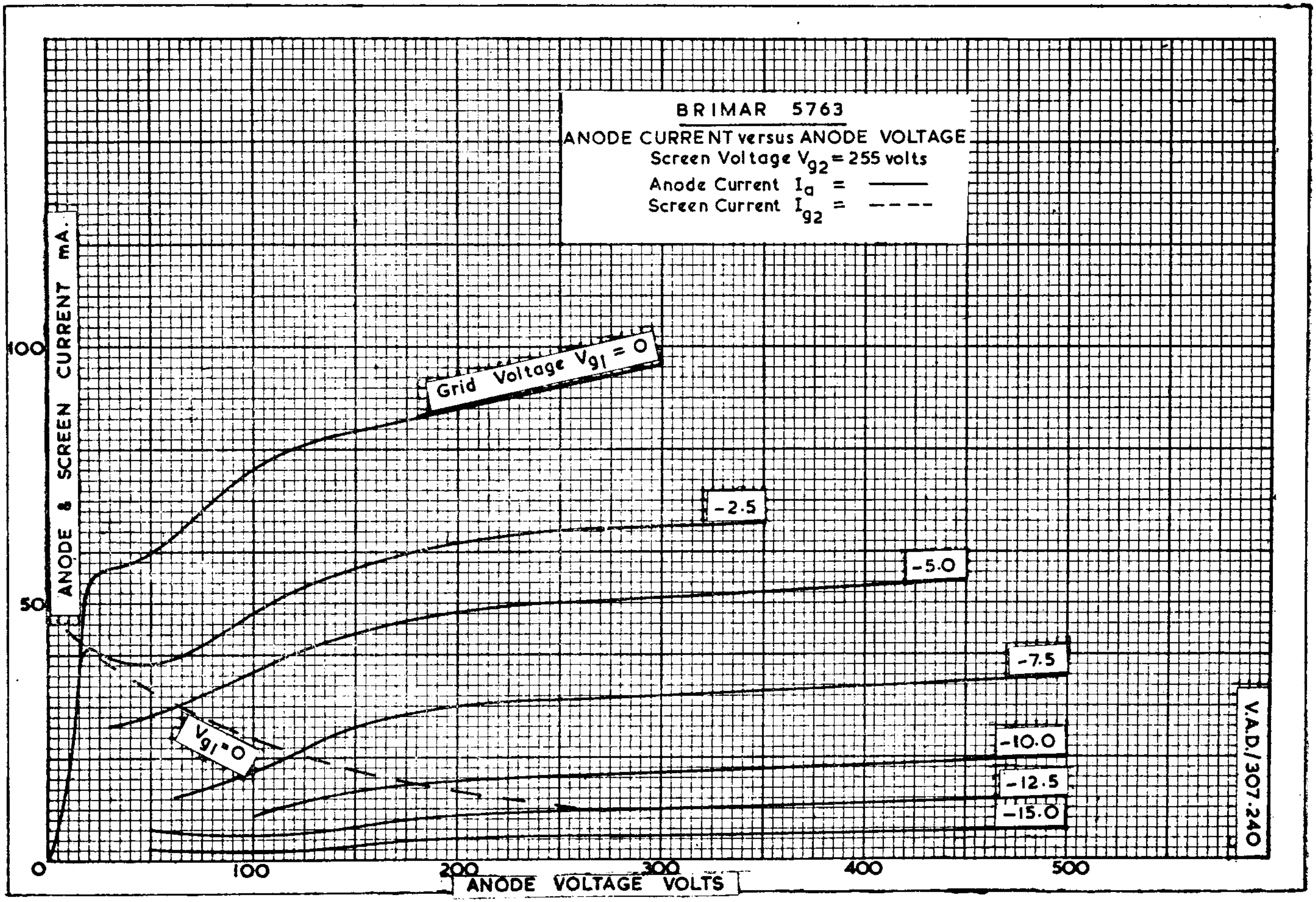
5763 AS A FREQUENCY MULTIPIER.

DOUBLER to 100Mc/s $R_1 = 75k\Omega$.

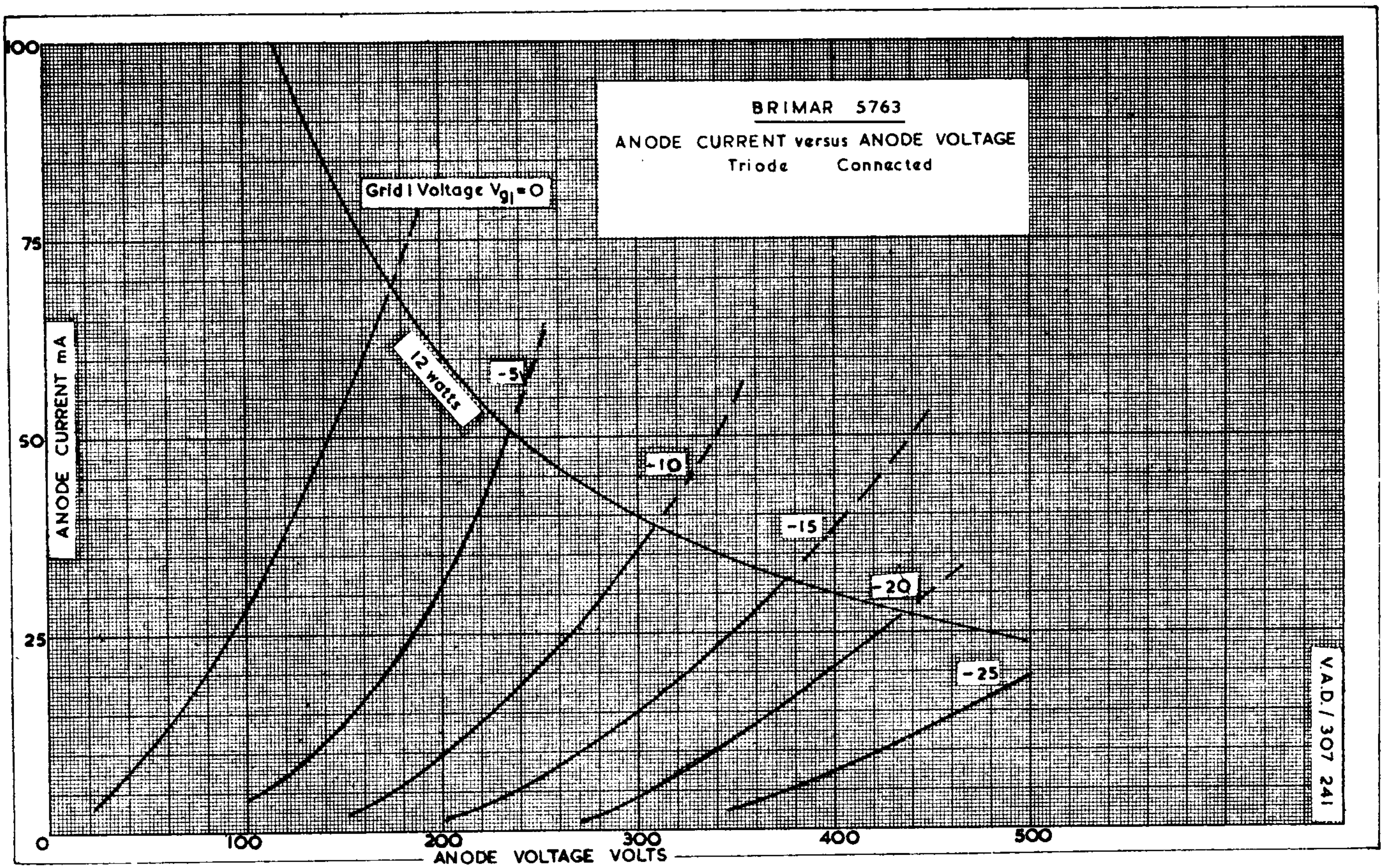
TREBLER to 150Mc/s $R_1 = 100k\Omega$.

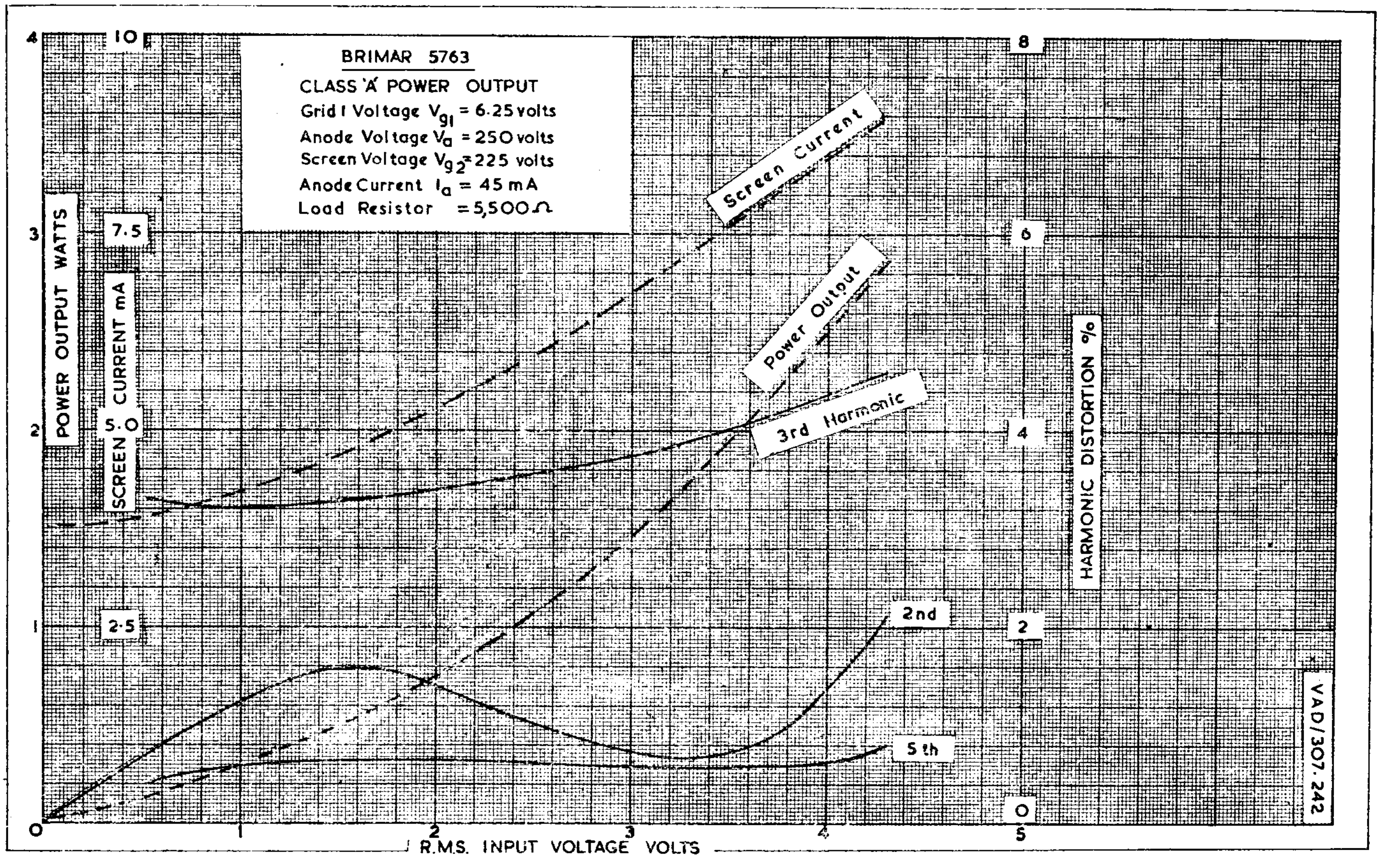
NOTE :- ALL CONDENSER VALUES IN pF UNLESS OTHERWISE SHOWN.

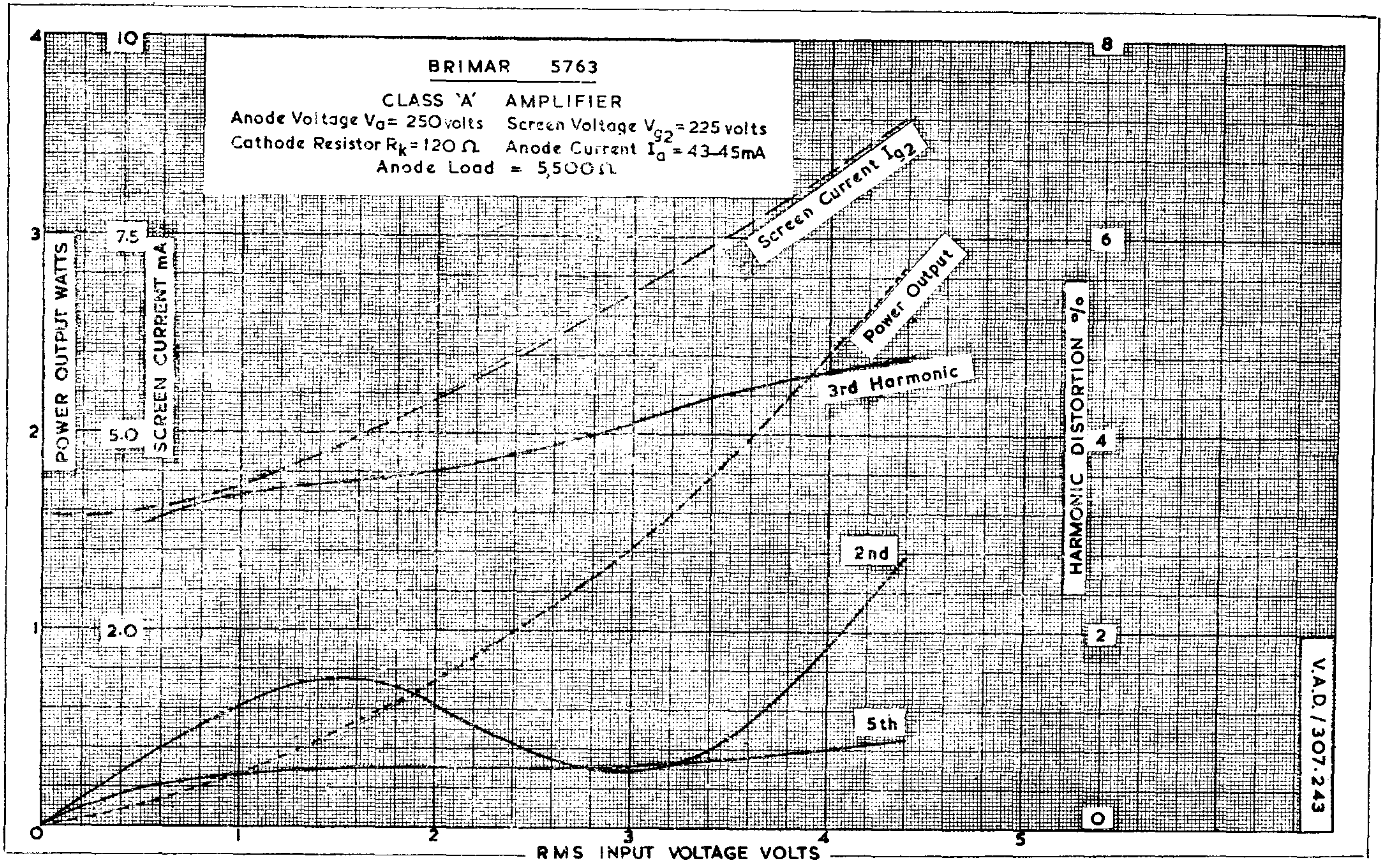

BRIMAR 5763
ANODE & SCREEN CURRENT versus ANODE VOLTAGE
Screen Voltage V_{g2} = 250 volts
Anode Current I_a = ——
Screen Current I_{g2} = — — —
Grid 1 Current I_{g1} = - - - - - -
Grid 1 Voltage V_{g1} = +15 volts
+15
+10
+10
+5
+5
0
-5
-10
-15
+15
+10
+5
0
CONTROL GRID CURRENT mA
0
10
20
30
40
50
ANODE & SCREEN CURRENT mA
0
100
200
300
ANODE VOLTAGE VOLTS
100
200
300
400
V.A.D./ 307.239

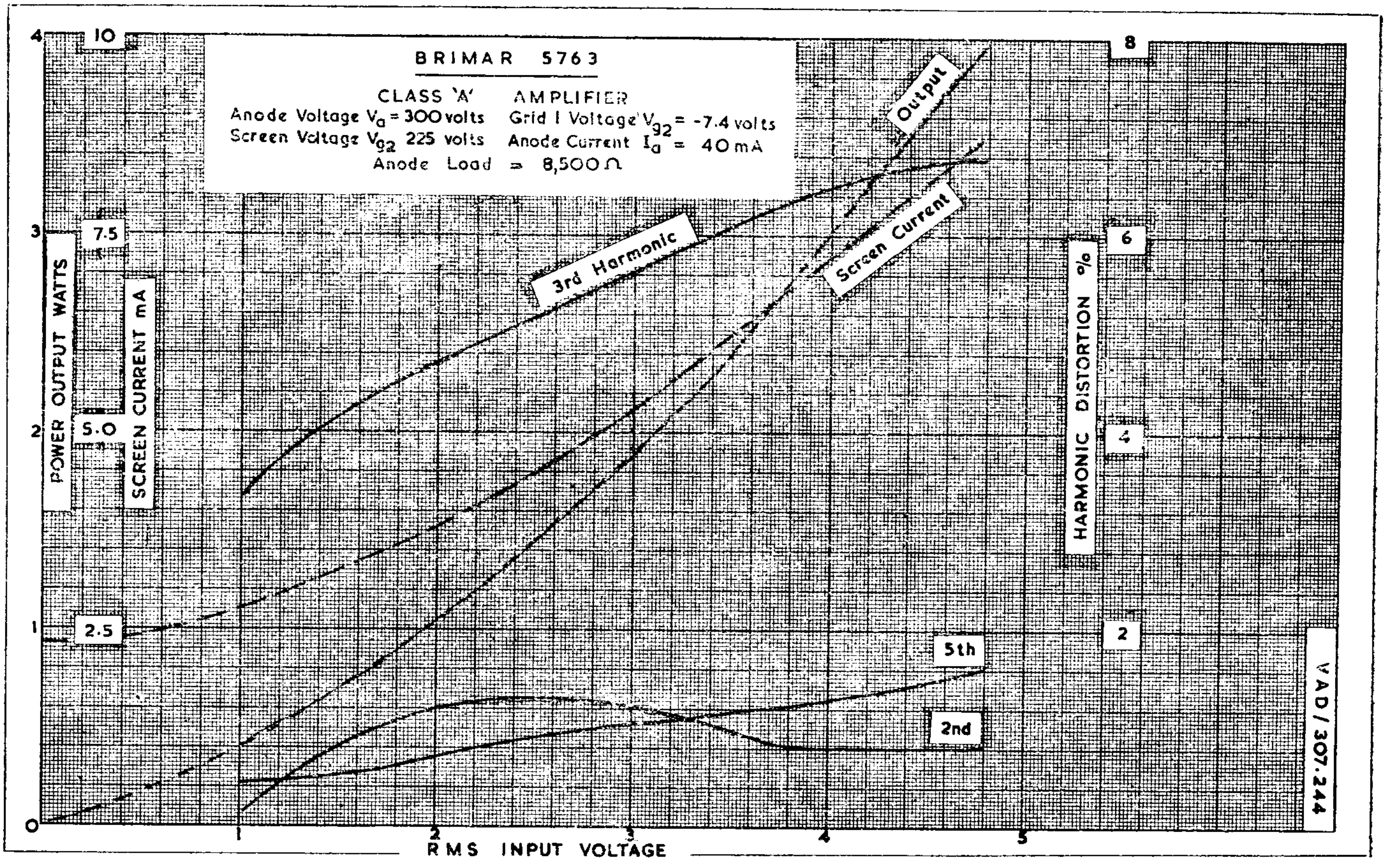


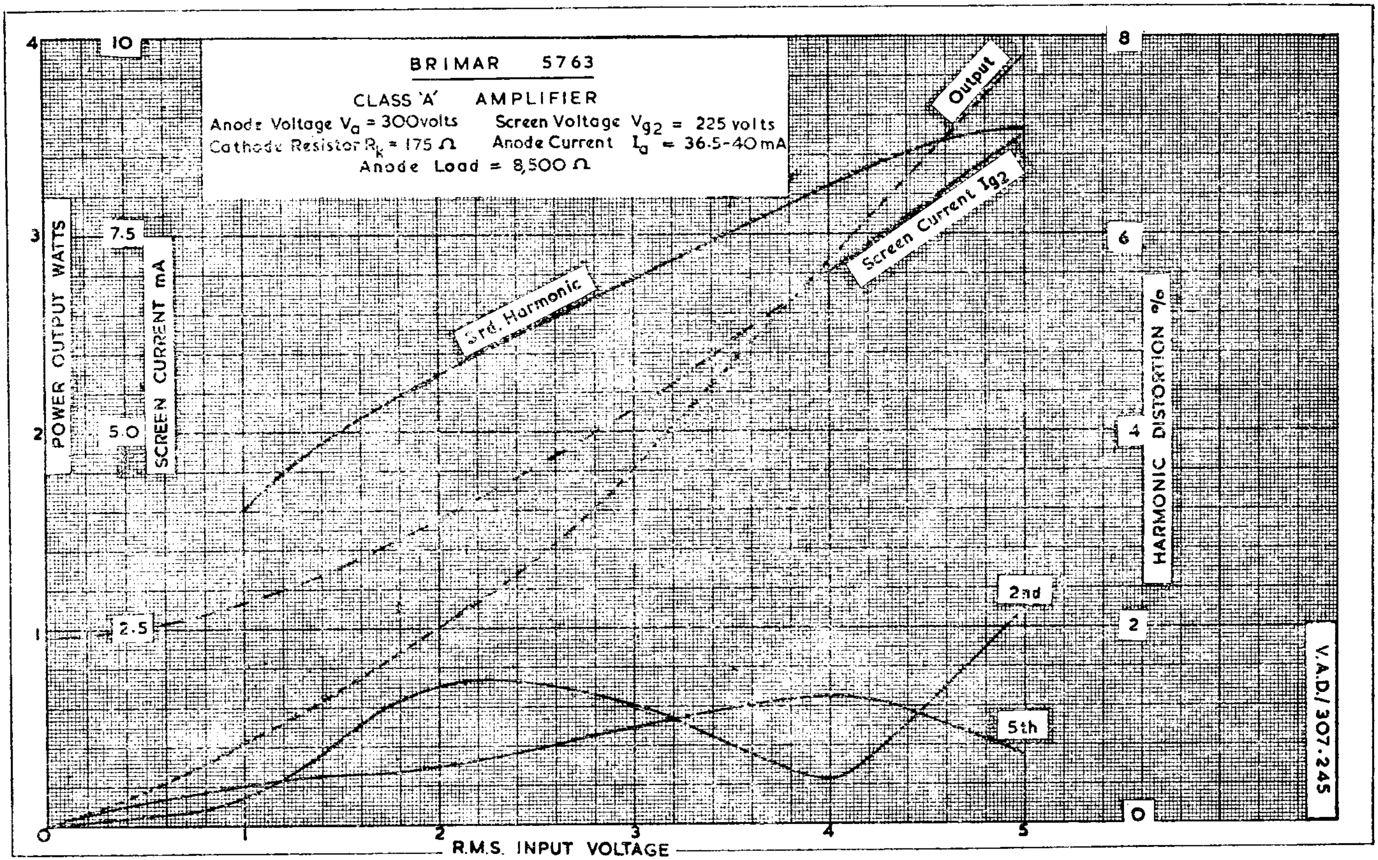
BRIMAR 5763
ANODE CURRENT versus ANODE VOLTAGE
Screen Voltage V_{g2} = 255 volts
Anode Current I_a = ———
Screen Current I_{g2} = - - - -
Grid Voltage V_{g1} = O
-2.5
-5.0
-7.5
-10.0
-12.5
-15.0
V_{g1} = O
ANODE & SCREEN CURRENT mA.
100
50
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
V.A.D./307.240


BRIMAR 5763
ANODE CURRENT versus ANODE VOLTAGE
Triode Connected
Grid I Voltage V_{g1} = 0
12 watts
-5
-10
-15
-20
-25
ANODE CURRENT mA
ANODE VOLTAGE VOLTS
0
100
200
300
400
500
25
50
75
100
V.A.D./307 241

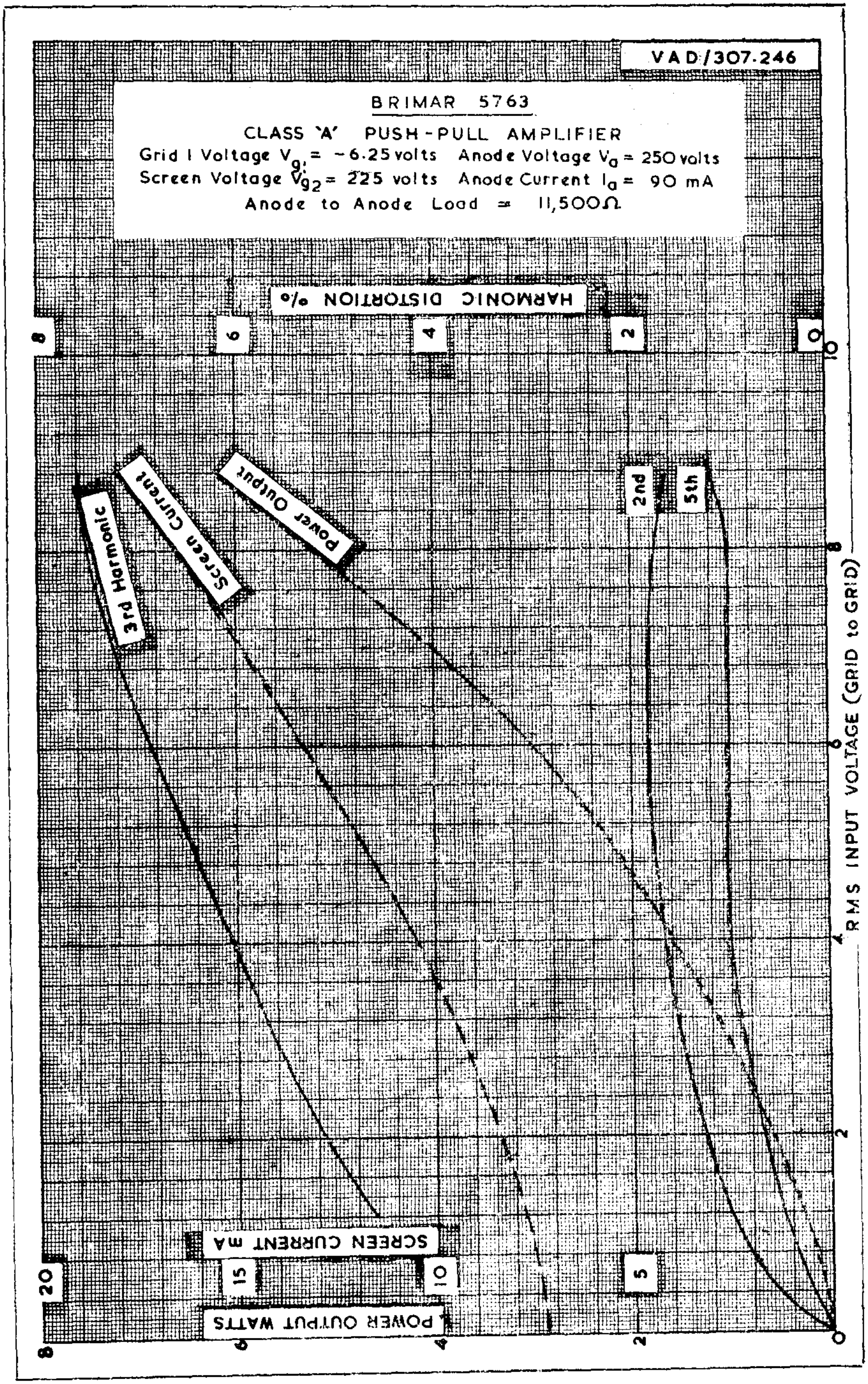

BRIMAR 5763
CLASS 'A' POWER OUTPUT
Grid I Voltage V_{g1} = 6.25 volts
Anode Voltage V_a = 250 volts
Screen Voltage V_{g2} = 225 volts
Anode Current I_a = 45 mA
Load Resistor = 5,500 Ω
Screen Current
Power Output
3rd Harmonic
2nd
5th
POWER OUTPUT WATTS
SCREEN CURRENT mA
HARMONIC DISTORTION %
R.M.S. INPUT VOLTAGE VOLTS
VAD/307. 242

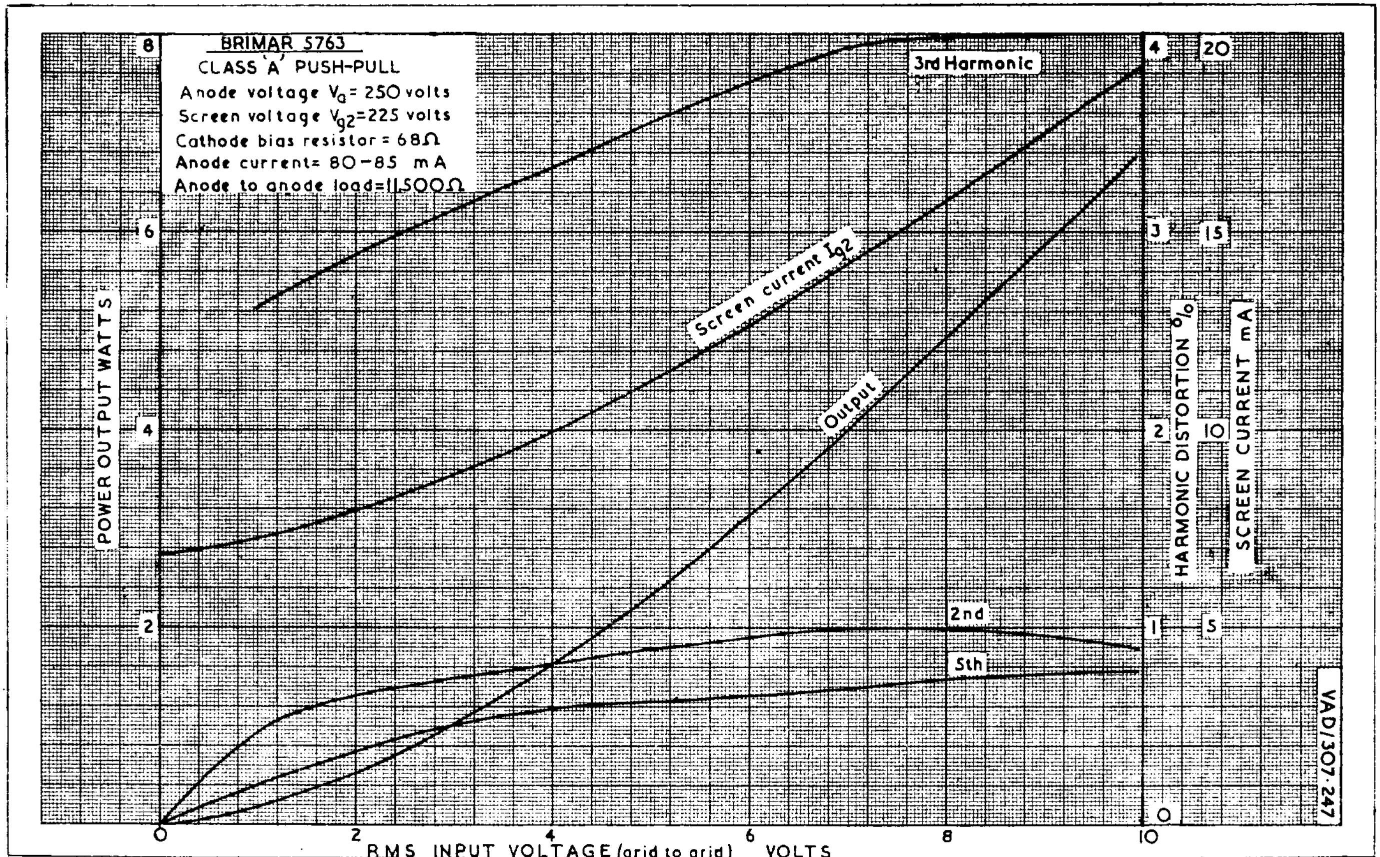

BRIMAR 5763
CLASS 'A' AMPLIFIER
Anode Voltage Va= 250 volts Screen Voltage Vg2 = 225 volts
Cathode Resistor Rk = 120 Ω Anode Current Ia = 43-45mA
Anode Load = 5,500 Ω
Screen Current Ig2
Power Output
3rd Harmonic
2nd
5th
POWER OUTPUT WATTS
SCREEN CURRENT mA
HARMONIC DISTORTION %
RMS INPUT VOLTAGE VOLTS
V.A.D. / 307.243

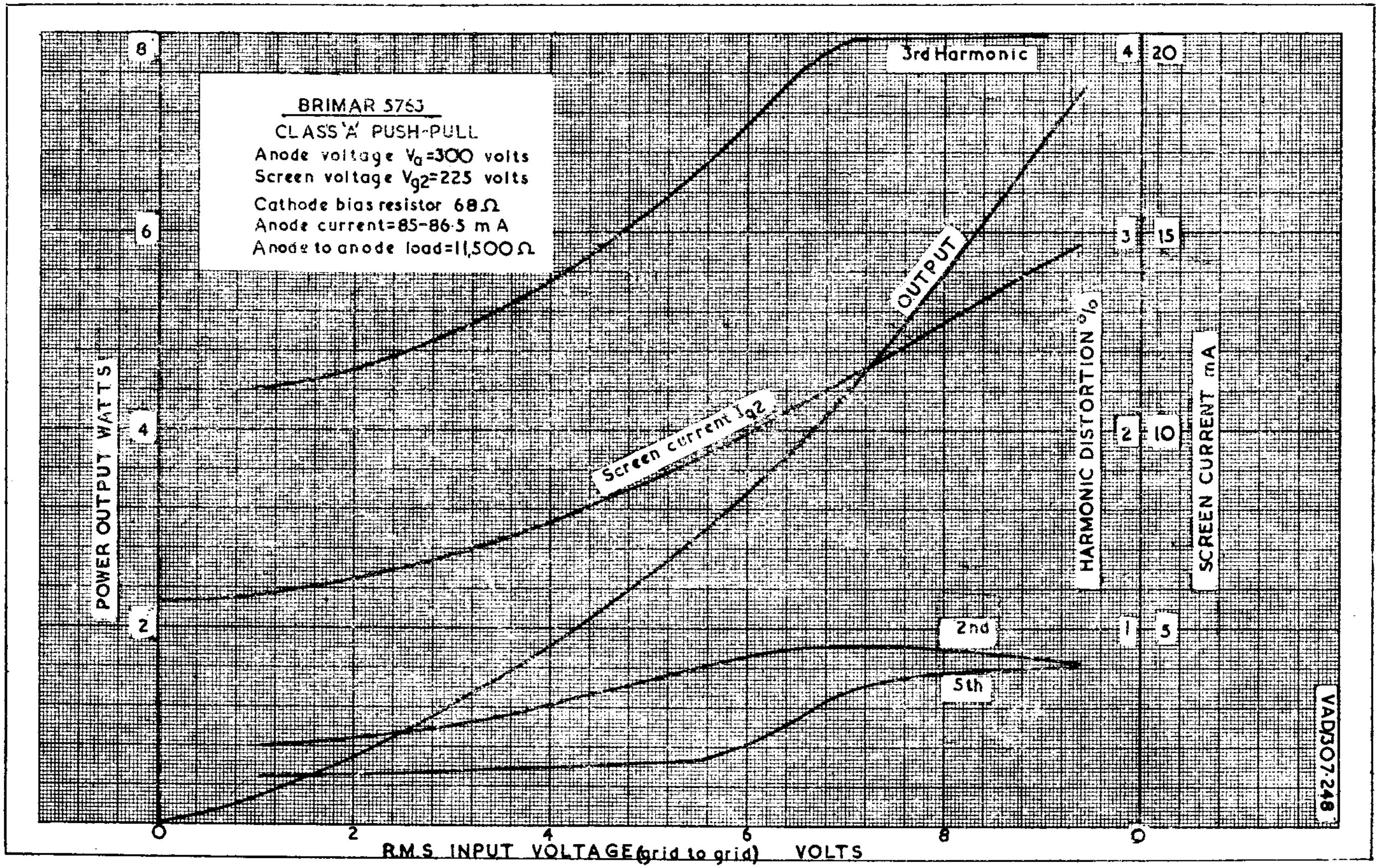

BRIMAR 5763
CLASS 'A' AMPLIFIER
Anode Voltage Va = 300 volts
Grid I Voltage Vg2 = -7.4 volts
Screen Voltage Vg2 225 volts
Anode Current Ia = 40 mA
Anode Load = 8,500 Ω
Output
Screen Current
3rd Harmonic
5th
2nd
POWER OUTPUT WATTS
SCREEN CURRENT mA
HARMONIC DISTORTION %
RMS INPUT VOLTAGE
VAD/307.244
0
1
2
3
4
5
2.5
5.0
7.5
10
6
8

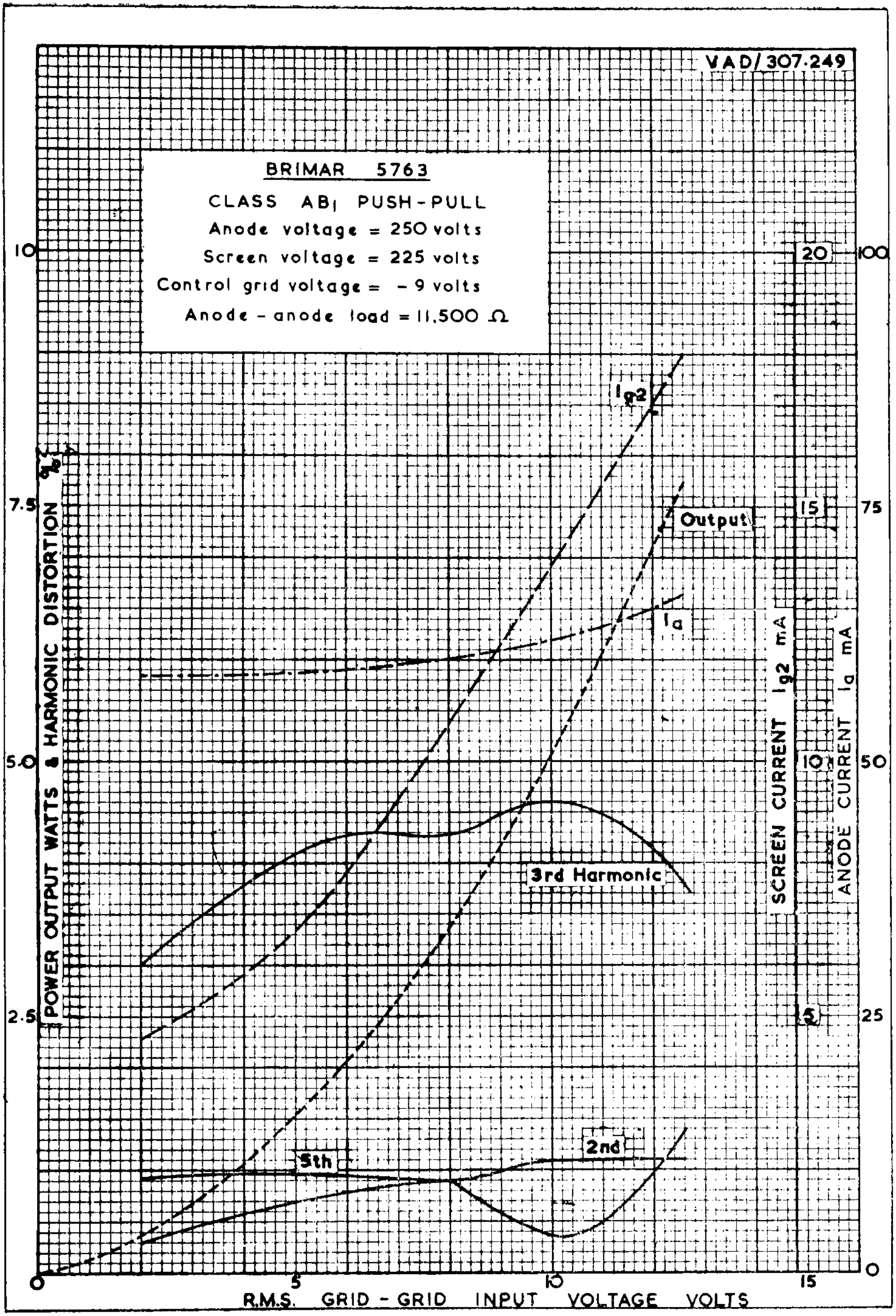


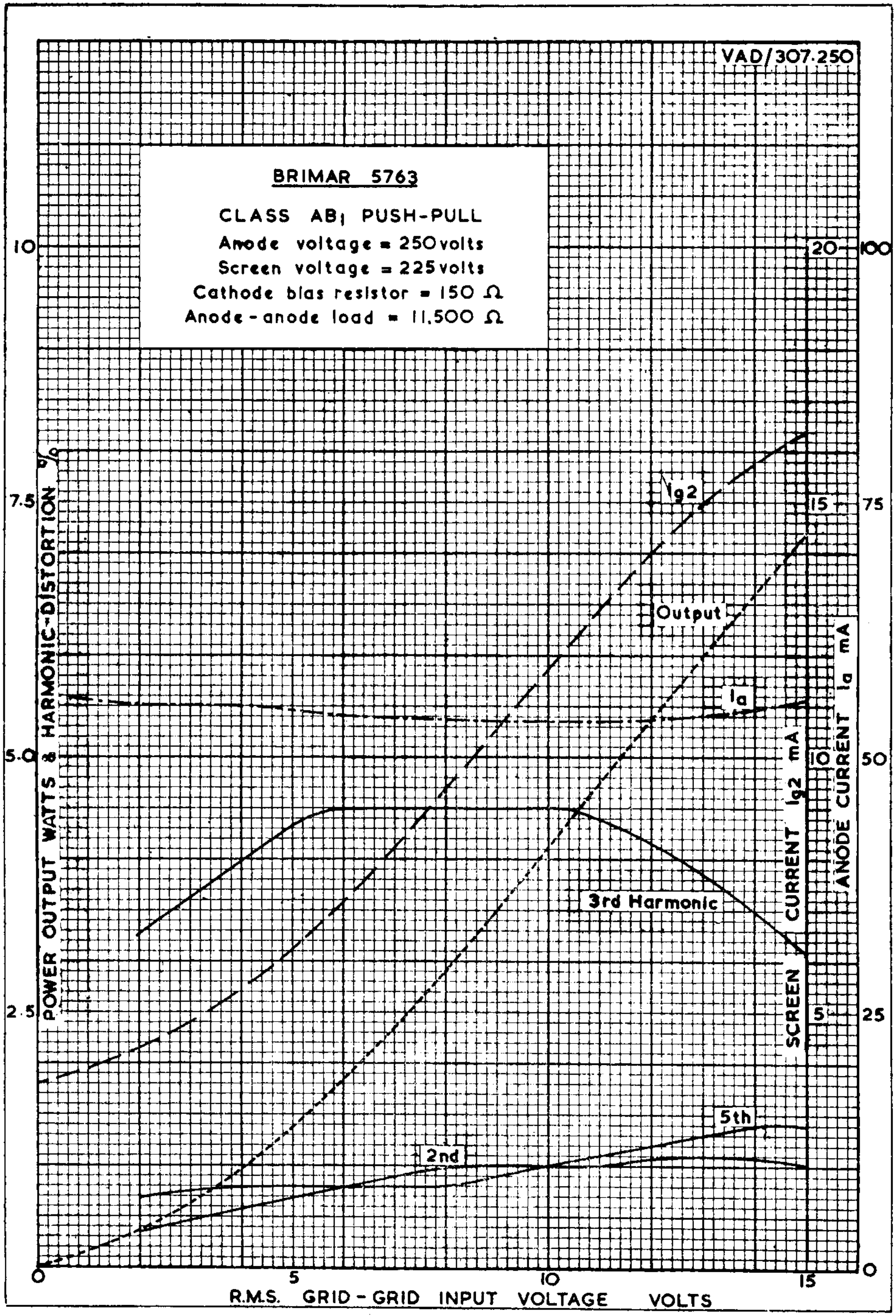
BRIMAR 5763
CLASS 'A' AMPLIFIER
Anode Voltage V_a = 300volts
Screen Voltage V_{g2} = 225 volts
Cathode Resistor R_k = 175 Ω
Anode Current I_a = 36.5-40 mA
Anode Load = 8,500 Ω
Output
Screen Current I_{g2}
3rd. Harmonic
2nd
5th
POWER OUTPUT WATTS
SCREEN CURRENT mA
HARMONIC DISTORTION %
R.M.S. INPUT VOLTAGE
V.A.D./ 307.245
0
1
2
3
4
5
10
7.5
5.0
2.5
8
6
2


VAD/307-246
BRIMAR 5763
CLASS 'A' PUSH-PULL AMPLIFIER
Grid I Voltage V_{g_1} = −6.25 volts Anode Voltage V_a = 250 volts
Screen Voltage V_{g_2} = 225 volts Anode Current I_a = 90 mA
Anode to Anode Load = 11,500Ω
HARMONIC DISTORTION %
8
6
4
2
0
3rd Harmonic
Screen Current
Power Output
2nd
5th
RMS INPUT VOLTAGE (GRID to GRID)
10
8
6
4
2
0
SCREEN CURRENT mA
20
15
10
5
POWER OUTPUT WATTS
8
6
4
2
0

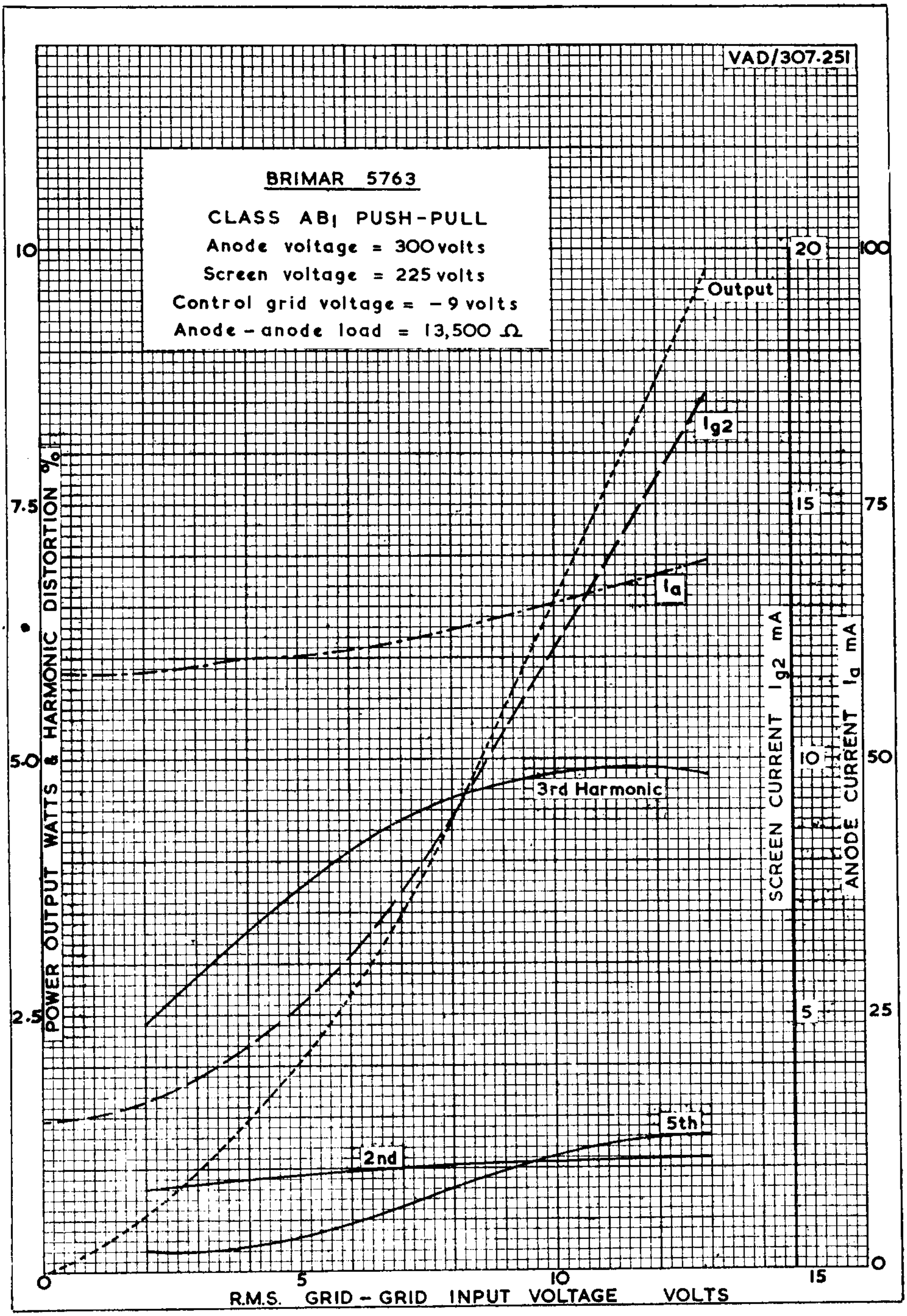

BRIMAR 5763
CLASS 'A' PUSH-PULL
Anode voltage Va = 250 volts
Screen voltage Vg2 = 225 volts
Cathode bias resistor = 68Ω
Anode current = 80–85 mA
Anode to anode load = 11,500Ω
3rd Harmonic
Screen current Ig2
Output
2nd
5th
POWER OUTPUT WATTS
HARMONIC DISTORTION %
SCREEN CURRENT mA
RMS INPUT VOLTAGE (grid to grid) VOLTS
VAD/307·247
8
6
4
2
0
10
20
15
5
3
1

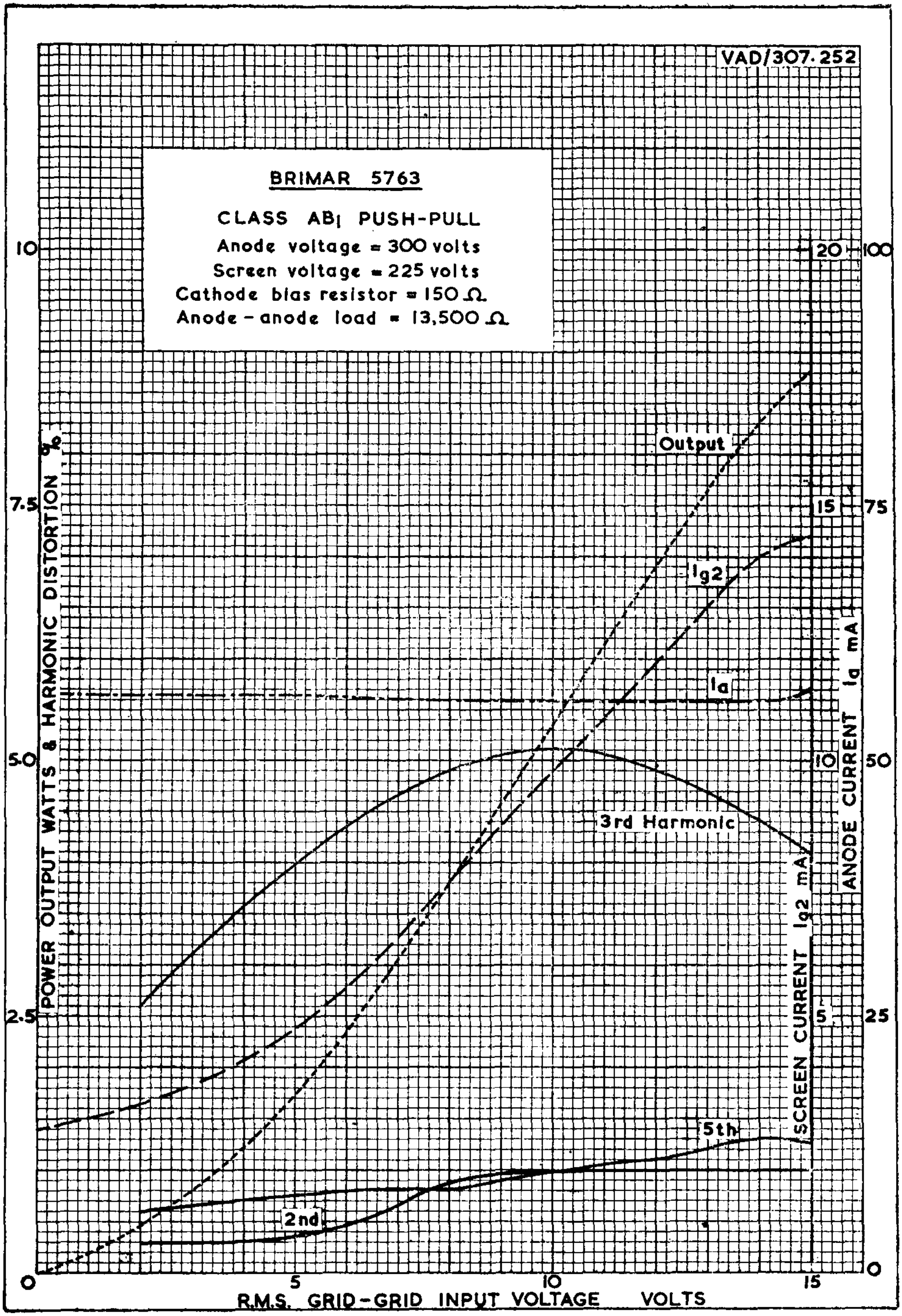

BRIMAR 5763
CLASS 'A' PUSH-PULL
Anode voltage V_a=300 volts
Screen voltage V_{g2}=225 volts
Cathode bias resistor 68 Ω
Anode current=85-86·5 mA
Anode to anode load=11,500 Ω
3rd Harmonic
OUTPUT
Screen current I_{g2}
2nd
5th
POWER OUTPUT WATTS
HARMONIC DISTORTION %
SCREEN CURRENT mA
R.M.S. INPUT VOLTAGE (grid to grid) VOLTS
VAD/307·248


VAD/307.249
BRIMAR 5763
CLASS AB1 PUSH-PULL
Anode voltage = 250 volts
Screen voltage = 225 volts
Control grid voltage = -9 volts
Anode-anode load = 11,500 Ω
Ig2
Output
Ia
3rd Harmonic
2nd
5th
POWER OUTPUT WATTS & HARMONIC DISTORTION %
SCREEN CURRENT Ig2 mA
ANODE CURRENT Ia mA
R.M.S. GRID-GRID INPUT VOLTAGE VOLTS
0
5
10
15
2.5
5.0
7.5
10
20
25
50
75
100

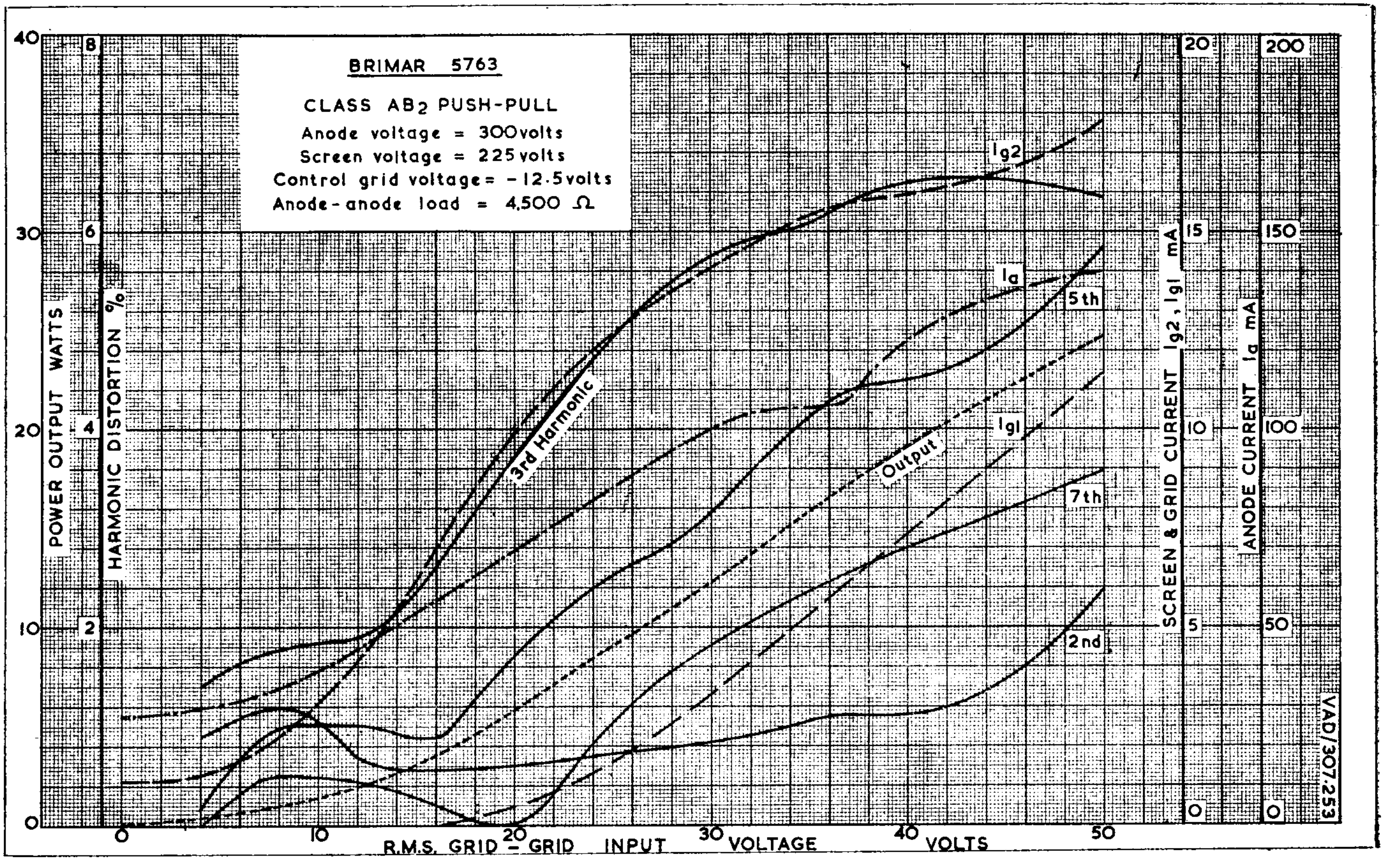


VAD/307.250
BRIMAR 5763
CLASS AB1 PUSH-PULL
Anode voltage = 250 volts
Screen voltage = 225 volts
Cathode bias resistor = 150 Ω
Anode-anode load = 11,500 Ω
POWER OUTPUT WATTS & HARMONIC-DISTORTION %
SCREEN CURRENT Ig2 mA
ANODE CURRENT Ia mA
Ig2
Output
Ia
3rd Harmonic
5th
2nd
R.M.S. GRID-GRID INPUT VOLTAGE VOLTS
0
5
10
15
2.5
5.0
7.5
10
20
100
75
50
25

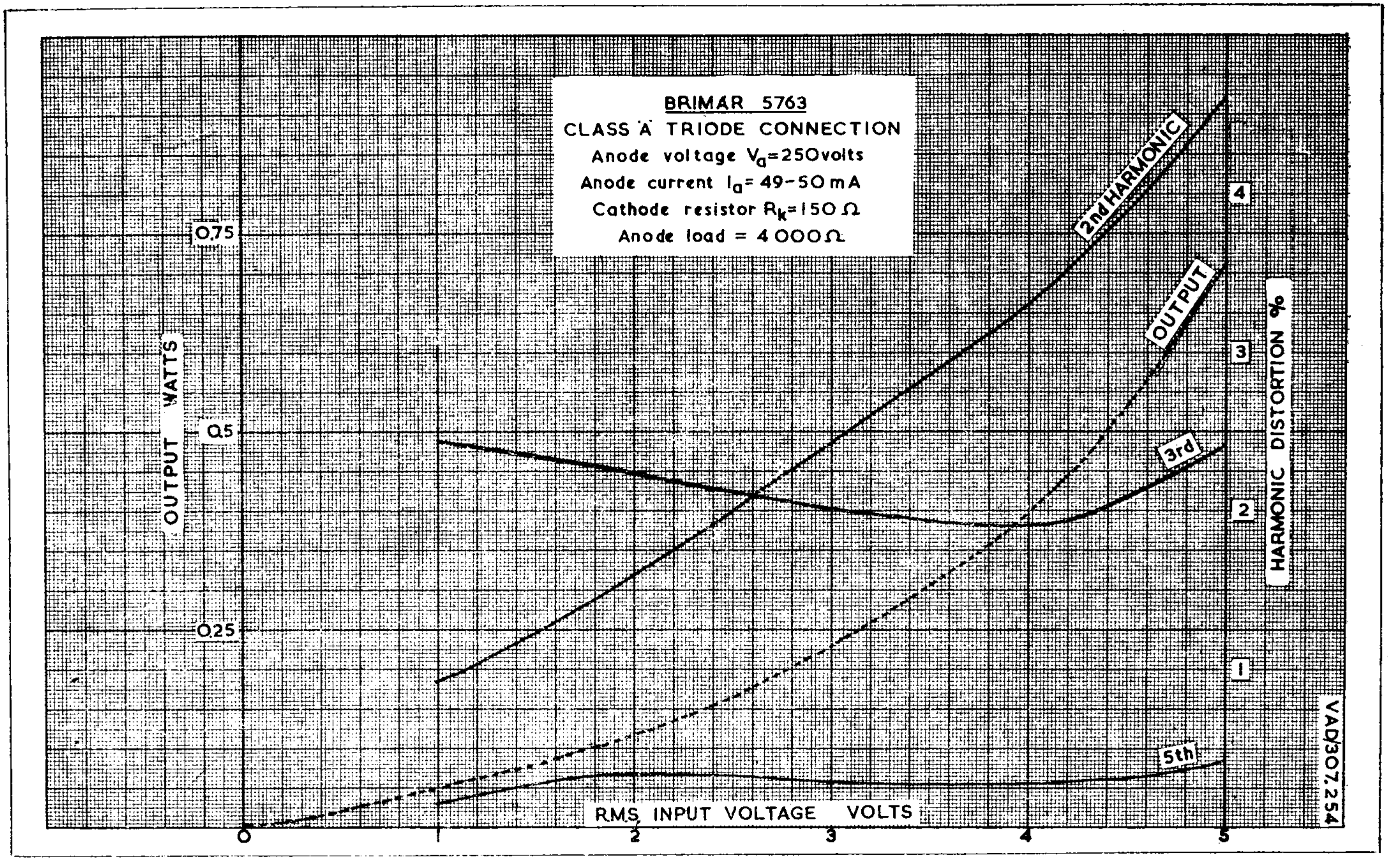

VAD/307·251
BRIMAR 5763
CLASS AB1 PUSH-PULL
Anode voltage = 300 volts
Screen voltage = 225 volts
Control grid voltage = −9 volts
Anode-anode load = 13,500 Ω
Output
Ig2
Ia
3rd Harmonic
5th
2nd
POWER OUTPUT WATTS & HARMONIC DISTORTION %
SCREEN CURRENT Ig2 mA
ANODE CURRENT Ia mA
R.M.S. GRID-GRID INPUT VOLTAGE VOLTS
0
5
10
15
2.5
5.0
7.5
10
20
25
50
75
100



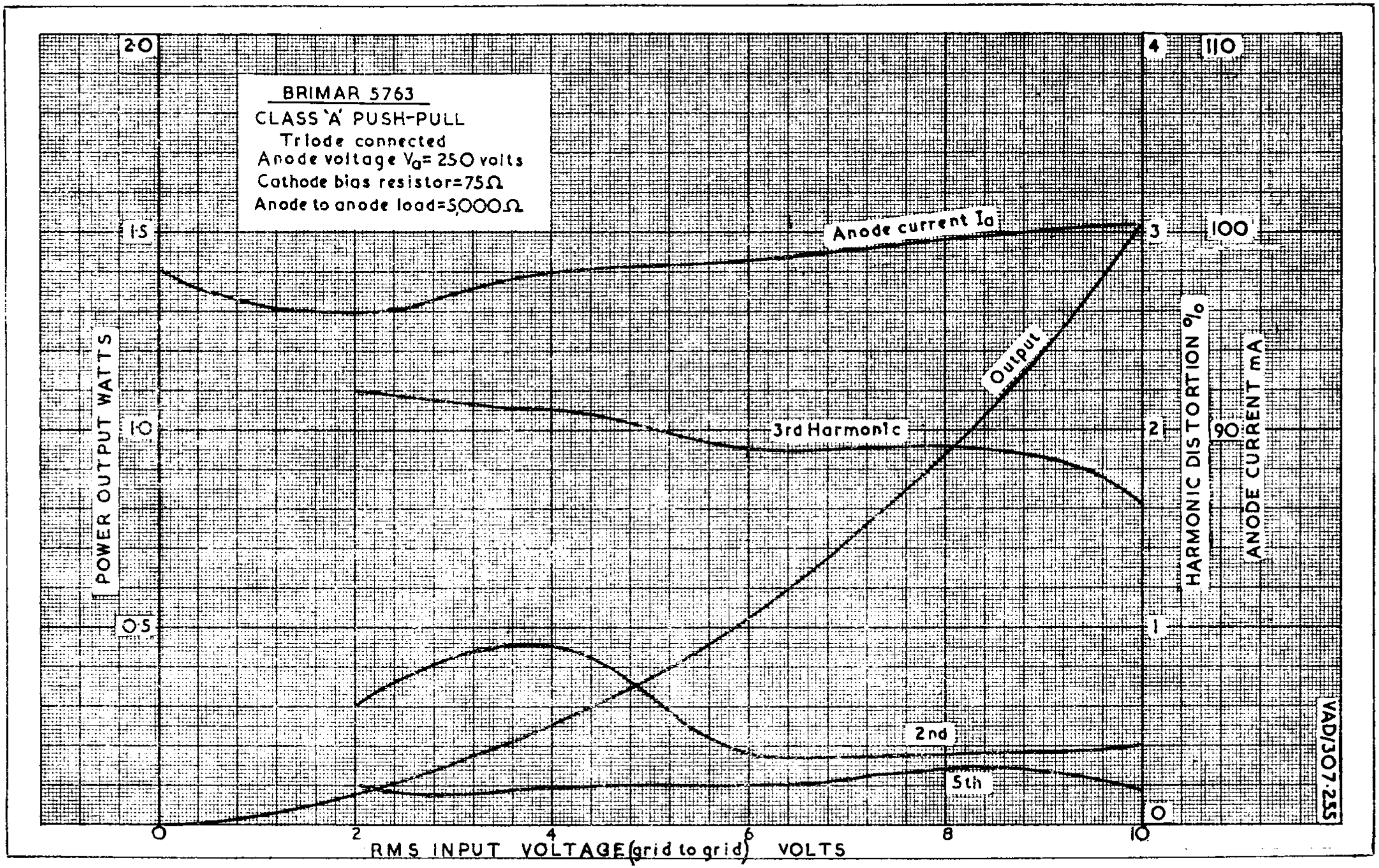
VAD/307.252
BRIMAR 5763
CLASS AB1 PUSH-PULL
Anode voltage = 300 volts
Screen voltage = 225 volts
Cathode bias resistor = 150 Ω
Anode-anode load = 13,500 Ω
Output
Ig2
Ia
3rd Harmonic
5th
2nd
POWER OUTPUT WATTS & HARMONIC DISTORTION %
SCREEN CURRENT Ig2 mA
ANODE CURRENT Ia mA
R.M.S. GRID-GRID INPUT VOLTAGE VOLTS
0
5
10
15
2.5
5.0
7.5
10
20
25
50
75
100



BRIMAR 5763
CLASS AB_2 PUSH-PULL
Anode voltage = 300volts
Screen voltage = 225volts
Control grid voltage= −12.5volts
Anode-anode load = 4,500 Ω
POWER OUTPUT WATTS
HARMONIC DISTORTION %
R.M.S. GRID − GRID INPUT VOLTAGE VOLTS
SCREEN & GRID CURRENT I_{g2}, I_{g1} mA
ANODE CURRENT I_a mA
3rd Harmonic
Output
I_{g2}
I_a
I_{g1}
5th
7th
2nd
VAD/307.253



BRIMAR 5763
CLASS 'A' TRIODE CONNECTION
Anode voltage V_a=250volts
Anode current I_a= 49-50 mA
Cathode resistor R_k=150 Ω
Anode load = 4000Ω
2nd HARMONIC
OUTPUT
3rd
5th
OUTPUT WATTS
0.75
0.5
0.25
HARMONIC DISTORTION %
4
3
2
1
RMS INPUT VOLTAGE VOLTS
0
1
2
3
4
5
VAD/307.254


BRIMAR 5763
CLASS 'A' PUSH-PULL
Triode connected
Anode voltage V_a= 250 volts
Cathode bias resistor=75Ω
Anode to anode load=5,000Ω
POWER OUTPUT WATTS
HARMONIC DISTORTION %
ANODE CURRENT mA
RMS INPUT VOLTAGE (grid to grid) VOLTS
Anode current I_a
Output
3rd Harmonic
2nd
5th
VAD/307·255

BRIMAR

WIDE ANGLE DEFLECTION CIRCUIT FOR C14BM

CIRCUIT REPORT VAD/700.6

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

Issued May, 1952

DEFLECTION CIRCUITS FOR WIDE ANGLE CATHODE RAY TUBES

CIRCUIT I For C14BM

SUMMARY: This report describes a line and frame time base suitable for use with the Brimar C14BM wide angle deflection rectangular cathode ray tube. Operation is from a 200 volt HT rail, and the E.H.T. is supplied from the line fly-back pulses. An efficiency diode provides a boosted HT supply which is used for both frame and line output stages. An auto wound line output transformer is employed with an iron dust core material.

1.0 GENERAL: The advent of large screen wide angle deflection cathode ray tubes has increased the problems associated with the provision of adequate power for the line deflector coils and the required high value of E.H.T. from the fly-back pulses. In the case of the C14BM the deflection angle has been increased from some 50° to 70°, and in order to prevent the electron beam from striking the inside of the neck at the extreme ends of its scan the neck diameter has been increased from a nominal of 35 mm. to approximately 1-7/16 in. The centre of deflection of the beam is brought forward towards the screen to prevent corner cutting, so that a shorter length deflector coil is required than has hitherto been customary.

These factors all add to increase the scanning power required, and with the additional demands caused by a higher E.H.T. voltage mean that the C14BM requires nearly 2½ times the scanning power that was needed for the 12 in. tubes.

This situation is made more difficult by the requirements for AC/DC operation, which set a maximum limit of 200 volts to the HT rail for the receiver. The total power required for the line output stage scanning a C14BM is approximately 40 watts at 12 kV E.H.T. Assuming that the valves are 100% efficient this would mean an HT current of 200 mA for the line output stage alone, and this, in practice, would be much higher due to valve and circuit losses.

If the stored energy is recovered from the magnetic circuit of the line output transformer and deflector coils and fed back to the output stage, the time base has only to supply the losses; indeed a perfect circuit, once it had reached its operating condition, would require no power to maintain it. The scan energy contained in the overswing is allowed to flow back through the deflector coils before the output valve begins its cycle of operation and provides almost one half of the scan amplitude. Linearity is controlled by the efficiency diode and a linearity coil and associated condensers. As nearly half the scan can be obtained in this way the power requirements of the line output valve are reduced. The DC voltage appearing across the load of the efficiency diode may be added in series with the HT line to augment the voltage supply to the line output valve. Although the power requirements of the line output stage are greatly reduced by these means a large valve is still necessary as despite the great reduction obtained in the external power requirements, the internal 'circulating' power is the full amount, and has to be controlled by the output valve.

Scan amplitude, in the case of the line, is controlled by a variable inductor shunted across part of the line output transformer diverting some of the power from the scan coils.

E.H.T. voltage is obtained by half wave rectification of the positive fly-back pulses in the line output valve anode, which are stepped up by the overwinding on the output transformer.

The frame time base is conventional, and is operated from the boosted HT rail. This is desirable, as it is difficult to obtain the large linear current swing required when the output valve is operated from a 200 volt rail. A triode output valve is employed and very little power is required by this part of the circuit, so that the additional current can be readily supplied by the boosted HT rail.

2.0 THE LINE TIME BASE:

2.1 Line Oscillator: To obtain the maximum E.H.T. and boost voltages the fly-back should be as rapid as possible, and to ensure this the grid of the output valve must be cut off very rapidly and held at cut-off during the fly-back period. At this time the anode of the output valve is highly positive so that a considerable negative voltage is required for complete cut-off.

A multivibrator oscillator using a 12AU7 valve is employed to produce the drive voltage as this type of oscillator permits a sharper cut off to be obtained than with a conventional blocking oscillator. The circuit is shown on 426·1. A 12AU7 double triode is used in an unsymmetrical multivibrator circuit, the frequency of which is adjusted by R1 and the amplitude by R5. The output from the anode of V2 is fed to a peaking circuit C6 R8, which inserts a negative spike, so that the wave shape is of the form shown on 426·4. This is applied to the grid of the 6CD6G and is 130 volts peak to peak, the negative spike being 45 volts peak amplitude.

2.2 Line Output Stage: The line output valve is the 6CD6G, which has a high peak anode current rating at low anode voltage. Abridged characteristics of this valve are given in Appendix 2. The screen grid is supplied from the 200 volt HT rail through a 5000 ohm dropping resistor, the actual screen voltage being 115 volts. A small amount of cathode bias must be provided to protect the valve in the event of failure of the drive voltage. In the circuit the anode dissipation of the 6CD6G without drive is approximately 25 watts, which although well over the maximum rating the valve has been found to withstand for short periods without harm. If desired, a fuse may be fitted in the HT line which will blow after some seconds if the drive fails.

When the fly-back pulse takes place the peak positive anode voltage rises to about 5 kV. Through the anode to grid capacity of the valve this appears as a positive pulse on the control grid which acts in opposition to the negative peaking pulse which is required to ensure that the valve is fully cut-off. To neutralise this positive pulse a negative pulse is obtained from tag 1 of the line output transformer and passed to the control grid through C8.

2.3 Efficiency Diode: The 6U4GT used as an efficiency diode has the advantage of a high peak heater to cathode voltage rating which renders unnecessary a separate highly insulated heater supply. A summary of the characteristics of this type is shown on Appendix 2.

This rectifier damps the overswing of the line scan, recovers the energy and delivers it to the circuit in two ways. Firstly it allows the energy to be passed into the deflector coils as a linearly decaying current which provides nearly half the scanning power. The action may be likened to a pair of valves operating in Class B push-pull where each valve supplies half the output, the operation passing from one to the other at the cut off point. Secondly the DC voltage appearing across the output of the efficiency diode is available for connection in series with the HT rail to the time base, and in this way operation from a higher HT voltage is possible. The boost voltage available is 180 volts, so that the total HT supply is 380 volts.

The peak heater to cathode voltage is 3·3 kV which is safely below the maximum of 3·85 kV. The 6U4GT employs a special type of heater assembly and insulation which permit such high peak heater to cathode voltages.

2.4 Linearity: Linearity is controlled by a coil with an adjustable dust core in conjunction with the condensers C11 and C12. In practice these condensers should be selected to a reasonable tolerance, say better than $\pm 10\%$, otherwise there may be insufficient inductance swing to cover production variations.

Linearity is also affected by the shape and amplitude of the drive voltage to the 6CD6G. Ideally, the drive amplitude should be adjusted so that the valve is working under full Class B conditions. If too much drive is applied the valve will run into Class C, and the position at which the scan transfers from the efficiency diode to the line output valve is affected. Overlap takes place and the centre of the picture is compressed into bright vertical bars.

The drive should be increased until the vertical bars appear and then reduced to just below the point at which they disappear.

2.5 Width Control: It is desirable to be able to control the width of the line scan without greatly affecting the E.H.T. voltage. This rules out the possibility of controlling by means of the voltages on the line output valve. A small part of the output transformer is shunted by a coil with an adjustable iron core, and this inductance shunts some of the current which normally would pass through the deflector coil.

A variation of about 10% in line amplitude is obtainable without any very significant change in E.H.T. voltage.

2.6 Line Output Transformer: A drawing showing the mechanical arrangement of the output transformer is shown on 426·3. The core material is Type U1, a dust iron manufactured by Messrs. Neosid Ltd. This material has not the exceptionally low losses of ceramic iron materials, nor is the permeability very high, being only of the order of 5. It has the advantage of being practically unsaturable so that no further sacrifice of permeability is lost through gapping.

Despite the apparent shortcomings of this material it has been possible to design a reasonably efficient circuit around it.

An auto-wound transformer is employed, the E.H.T. overwinding being a narrow wave wound coil over the wide output valve winding. The electrical specification and the winding details are given in Appendix 3.

The tapping for the cathode of the 6U4GT efficiency diode is selected to give optimum performance when an additional 15 mA is drawn from the boosted HT supply by the frame time base. If this additional current is not required the transformer turns ratio requires modification.

Great care must be taken with the construction of the transformer to prevent voltage breakdown and corona discharge. The voltage gradient across the windings is very high so that it is important that, particularly on the overwinding, no loose turns slip down the outside and cause breakdown between sections of the winding. Sharp bends or points on the connecting wires should be avoided or corona discharge to nearby bodies at low potential may take place. Such corona discharges not only place an additional load on the E.H.T. supply, reducing the available voltage, but give rise to interference spots on the picture which can only be satisfactorily removed by elimination of the discharge.

The self capacity of the windings must be kept to a minimum, particularly that of the overwinding. The rapidity of the fly-back pulse and the consequent value of the E.H.T. voltage depend on ensuring the lowest possible capacity across the line output.

The filament voltage winding for the 1T2 E.H.T. rectifier consists of 4-3/4 turns of polythene covered wire wound directly on the side limb of the transformer core so that the ends of the winding may be brought up directly to the rectifier.

2.7 Deflector Coil: No constructional details are given for the deflector coils as this is a problem rather closely connected with individual manufacturing abilities. The circuit has been designed for line coils of some 30 to 40 mH inductance. This inductance is quite normal and representative of general practice.

In order to reduce, as far as possible, deflection defocussing which becomes more serious with wide angle deflection tubes it is necessary to provide a magnetic field which is as nearly uniform as possible, over the whole of the deflection angle, so that the spot is not distorted or out of shape. This can be accomplished by a cosine distribution of the turns, i.e. the number of turns varies as the cosine of the angle around the circumference of the neck, the reference plane being horizontal. The ends of the windings which are bent up do not greatly influence the shape of the field, but it is advisable to arrange for the back end to bend up as sharply as possible. The front end should be arranged to follow the shape of the flare of the funnel of the tube as defined by the reference gauge, but should not be extended far up the flare of the tube. The purpose of the front shaping is to allow the deflector coils to locate on the neck as close to the screen as possible, thus bringing forward the centre of deflection so that the beam does not strike the inside of the tube neck. To this end the coils must be as short as possible consistent with obtaining adequate sensitivity, and should not be allowed to exceed 2 ins. in length.

In practice the cosine law winding is not suited to the C14BM and similar tubes with semi-flat screen faces. Where the radius of curvature of the screen surface is greater than that of the deflected beam, pin cushion distortion occurs, and the field distribution of the deflector coils must be modified to reduce this. Quite a good compromise between deflection defocussing and pin cushion distortion may be obtained by winding the coils with a cosine squared distribution. This yields a winding tapering more sharply than the cosine distributed winding and it becomes so thin that in practice the last 20 or 30 degrees may be omitted.

The cosine squared law may be approximated by winding the outer section of the coils with a smaller gauge of wire than the inner section together with a little shaping of the windings. By the use of a greater number of wire sizes the distribution may be approximated without shaping. It has been found better to wind the coils in the shape finally required with the ends bent to shape and bonded, as attempts to shape up to a flat coil lead to untidy ends as the outside turns are not long enough and pull down into a bunch. Although requiring a more complex jig the practice of winding the coils in the exact shape required has much to recommend it as this prevents damage to the insulation during the forming process, and if self-bonding wire is used, by passing a current through the coil in the jig a rigid winding is obtained which is repeatable in production.

To improve the sensitivity a magnetic yoke is required around the outside of the deflector coils. This can consist of a ring of material similar to that used for the line output transformer core, or may even consist of a large number of turns of soft iron wire. The important thing is to obtain a fairly good Q so that the losses are as low as possible.

Another method of obtaining the necessary distribution of the magnetic field is to use a castellated yoke which encloses the coils and controls the field distribution by the shape of the pole pieces. It is necessary to design the yoke for the radius of screen curvature relative to deflection radius of the tube on which it is to be used, but this may be outweighed by the great increase in sensitivity and Q obtained by this method.

2.8 E.H.T. Supply: The 1T2 rectifies the fly-back pulses which are stepped up by the overwind on the output transformer. The reservoir condenser is formed by the capacity between the CR Tube anode and the external conductive coating on the tube, which is of the order 0·001μF.

A curve showing the regulation of the E.H.T. supply is shown on 426·2. Over the normal working range the effective impedance is approximately 7 MΩ, which is not unduly high. The average beam current of the CR Tube varies between 30 and 70 μamperes; only on some picture titles and plain rasters does it usually rise above 100 μamperes. The reservoir condenser holds sufficient charge to supply the beam current requirements of normal picture highlights.

The 1T2 filament voltage cannot be measured in the normal way as it is of pulse waveform and is at high potential to earth. The correct operating condition is best determined by comparing the filament temperature with that of another valve operated from a 1·4 volt battery or other DC source.

3.0 Frame Time Base: The frame time base output valve may either be operated from the 200 volt HT rail or from the boosted HT line. In the first case a high slope valve is required which can supply a high peak anode current swing with only a low anode supply voltage. This indicates a pentode or tetrode valve of the output or large video class, and in fact suitable valves will give satisfactory operation under such conditions. Due to the low anode voltage, however, the valve swings out of the region of linear characteristics, and rather complex negative feedback arrangements are required to linearize the trace. Further, the high standing anode current through the output transformer primary makes it difficult and expensive to obtain the high primary inductance so necessary for efficient operation.

If, however, the time base is operated from the boosted HT supply the higher voltage enables the same power to be developed at a lower anode current, and, as in the case of the present circuit, quite a small triode is adequate for the output stage. The valve may be used over the linear portion of its characteristics, and the primary inductance of the output transformer may be high without the need for a bulky component.

3.1 Drive Circuit: A conventional blocking oscillator is used for this purpose supplying a 20 volts peak to peak signal to the output valve grid. One half of a 12BH7 is employed for this purpose. The other half of this double valve may be used for the frame output stage.

3.2 Output Stage: One half of a 12BH7 double triode will provide adequate frame scan, and the other half is used as the frame blocking oscillator. The alternative is a 12AU7 with both sections strapped in parallel to obtain a low impedance. A triode connected 6BW6 or 6V6 would serve equally well for this purpose, but these types are rather larger than necessary.

Vertical linearity is controlled by the variable cathode bias resistor R19, which is adjusted in conjunction with the amplitude control R16.

3.3 Output Transformer: The frame output transformer should have a primary inductance preferably greater than 30 Henries. The output valve anode current is less than 15 mA so that this inductance is not difficult to achieve. The required inductance may be obtained with Stalloy laminations, but a smaller and more efficient transformer can be made using a Permalloy or Mumetal core, providing it is gapped to prevent saturation by the DC anode current.

The transformer shown on the circuit has a turns ratio of 14 : 1 to match the specified inductance of the deflector coils.

3.4 Deflector Coils: The same remarks apply as in paragraph 2.7 where the line coils are described. The line coils are normally favoured as regards sensitivity, so the frame coils are wound over the line coils and consequently suffer from lower sensitivity than the line coils. The winding distribution of the frame coils should be the same as for the line to strike the best compromise between deflection defocussing and pin-cushion distortion.

The total coil inductance most suited for this circuit is between 10 and 15 mHenries. The largest possible wire gauge should be used, as at frame frequency the load appears predominately resistive, so that a low DC resistance reduces the copper loss which only goes to heat the coil.

3.5 Decoupling of Frame HT Supply: Adequate decoupling is required on the frame HT rail to prevent the appearance of line pulses on the frame supply which may interfere with the frame sychronisation and destroy the interlace. This decoupling must be isolated from the take off point on the boost HT rail which is not at ground potential to line frequency, but is part of the linearity control circuit. The 3·3 k resistor R23 is adequate for this purpose as the linearity circuit has a comparatively low Q.

4.0 Conclusions: This time base circuit is suitable for use with the C14BM, but the core material for the line output transformer does not enable the highest efficiency to be obtained. Further circuits are being developed around higher permeability and low loss core materials, which will enable higher E.H.T. voltages and scanning power to be obtained for the same power input.

For larger cathode ray tubes it will be necessary to use a higher efficiency line transformer core, and to pay more attention to suitable deflector coil shrouds to increase the scanning sensitivity.

In Appendix I are shown the operating conditions for this circuit in which are included the important peak voltage and current relationships. None of the valves is being operated at its maximum rating, although at first sight it would appear that the 12AU7 frame output valve is operating with excessive anode voltage. This valve is not overrun, as allowing for the volt drop in R23, R18 and R19 and in the transformer primary, the anode voltage is below the absolute maximum rating of 330 volts.

APPENDIX 1

OPERATING CONDITIONS OF LINE AND FRAME TIME BASE

HT Supply Voltage 200 volts DC

6CD6G	$V_{a\ (pk)}$	5·0 kV	$I_{k\ (dc)}$	94 mA
	$I_{a\ (dc)}$	76 mA	$I_{k\ (pk)}$	340 mA
	$I_{g2\ (dc)}$	17 mA	$V_{a\ (dc)}$	380 volts
	V_{g2}	115 volts		
6U4GT	$V_{h,\ k\ (pk)}$	3·3 kV	$I_{k\ (pk)}$	350 mA

Total HT current, line and frame = 112 mA at 200 volts
Frame time base current = 15 mA at 380 volts
Frame output valve anode current = 14·3 mA
Frame output valve cathode voltage = 15 volts DC

APPENDIX 2

ABRIDGED CHARACTERISTICS OF TIME BASE VALVES

6CD6G and 50CD6G

Ratings (Design Centre)

	6CD6G	50CD6G
V_h	6·3 volts	50 volts
I_h	2·5 amperes	0·3 ampere
$V_{a\ (max)}$	700 volts	
*$V_{a\ (pk)\ max}$	6,000 volts	
$p_{a\ (max)}$	15 watts	
$p_{g2\ (max)}$	3 watts	
$V_{g2\ (max)}$	175 volts	
*$V_{g1\ (pk)\ max}$	-150 volts	
c_{in}	26 pF	
c_{out}	10 pF	
$c_{g1,\ a}$	1.0 pF	

6U4GT and 25U4GT

Ratings (Absolute Values)

	6U4GT	25U4GT
V_h	6·3 volts	25 volts
I_h	1·2 amperes	0·3 ampere
$I_{a\ (pk)}$	660 mA	
$V_{h,\ k\ (pk)\ h+}$	500 volts	
*$V_{h,\ k\ (pk)\ h-}$	3,850 volts	
*P.I.V. (max)	3,850 volts	
$I_{k\ (dc)\ max}$	138 mA	
$c_{h,\ k}$	8·5 pF	

* The duty cycle must not exceed 15% of the scanning cycle, which is normally approximately 15 μseconds for a 405 line 25 frame interlaced system.

IT2

Ratings (Design Centre)

V_f	1·4 volts	$I_{a\ (pk)\ max}$	12 mA
I_f	0·14 ampere	$I_{a\ (dc)\ max}$	2 mA
P.I.V. (max)	15 kV	$c_{a,\ f}$	0·65 pF

12AU7

Ratings (Design Centre) Frame Scan Service

V_h	6·3 volts or 12·6 volts
I_h	0·3 ampere or 0·15 ampere
$V_{a\ (max)}$	300 volts
$p_{a\ (max)}$	2·75 watts each section
$I_{k\ (pk)}$	60 mA each section

12BH7

Ratings (Design Centre) Frame Scan Service

V_h	6·3 volts or 12·6 volts
I_h	0·6 amperes or 0·3 amperes
$V_{a\ (max)}$	500 volts
$p_{a\ (max)}$	3·5 watts each section
$I_{k\ (pk)}$	60 mA each section

APPENDIX 3

WINDING DETAILS OF LINE OUTPUT TRANSFORMER

Core Material: 2 Type U1 dust cores by Messrs. Neosid Ltd., Welwyn Garden City.

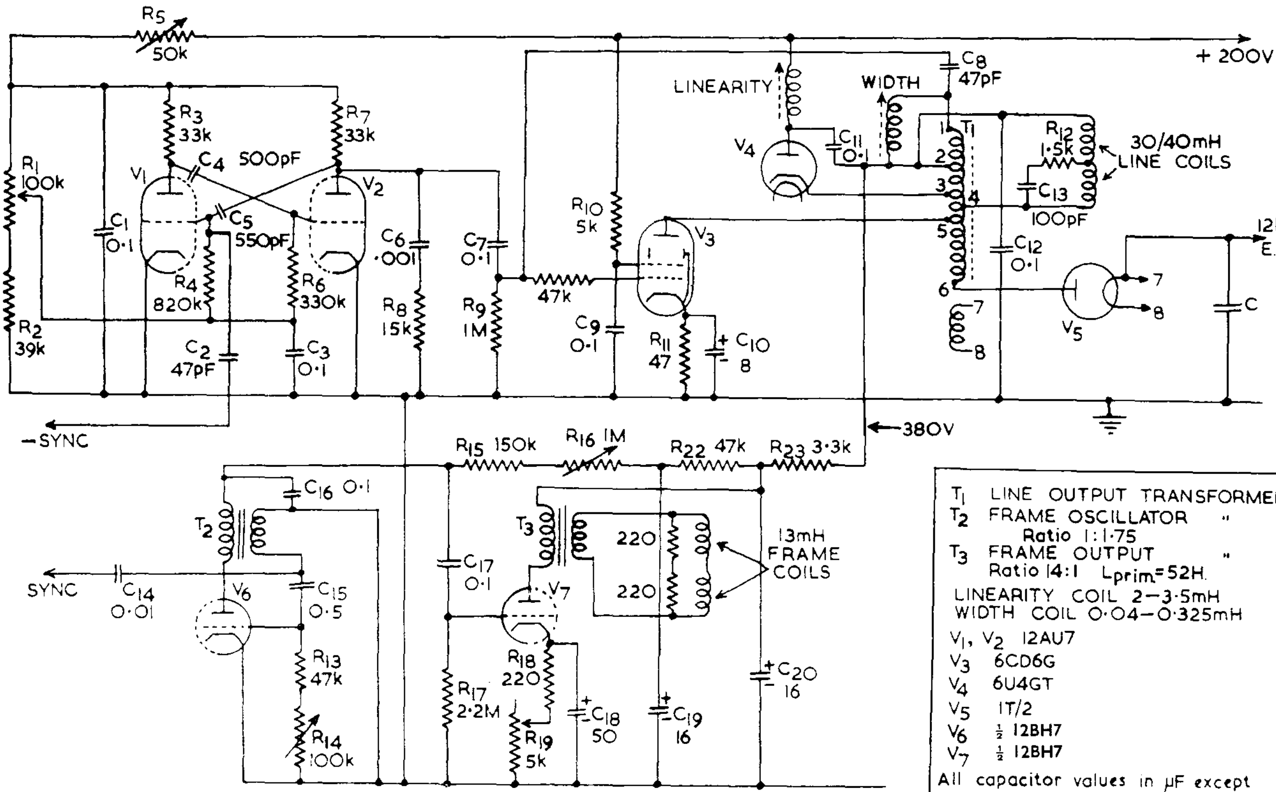
Former: Paxolin Tube 3/4 in. internal diameter, outside diameter 7/8 in. approx.

First Winding: 1 in. wide, 1/4 wave—1,400 turns of 36 SWG single silk enamelled, tapped at 80, 850 and 950 turns.
Douglas Wave Winder Gears 37—28/36—48 // 24—76.

Overwinding: 1/4 in. wide, single wave. 1,600 turns of 40 SWG double silk covered.
Douglas gears. 48—38/28—36 // 60—60.
No air gap in core.

ELECTRICAL CHARACTERISTICS

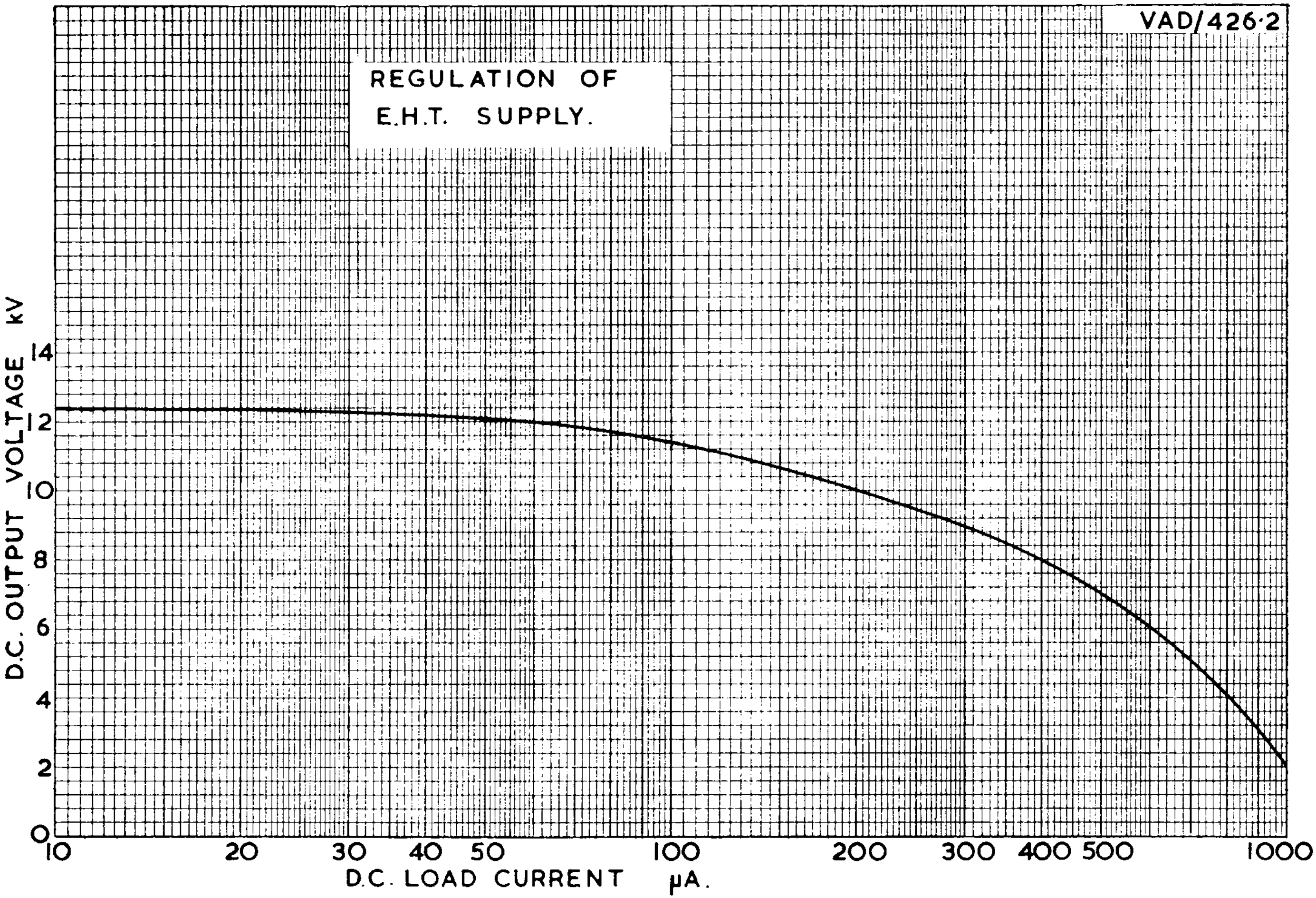
Tag No.	DC Resistance ohms	Inductance mH
2	5	0·4
3	45	45
4	50	56
5	78	140
6	380	650



T_1	LINE OUTPUT TRANSFORMER	
T_2	FRAME OSCILLATOR Ratio 1:1·75	"
T_3	FRAME OUTPUT Ratio 14:1 L_{prim}=52H.	"
LINEARITY COIL 2–3·5mH		
WIDTH COIL 0·04–0·325mH		
V_1, V_2	12AU7	
V_3	6CD6G	
V_4	6U4GT	
V_5	1T/2	
V_6	½ 12BH7	
V_7	½ 12BH7	

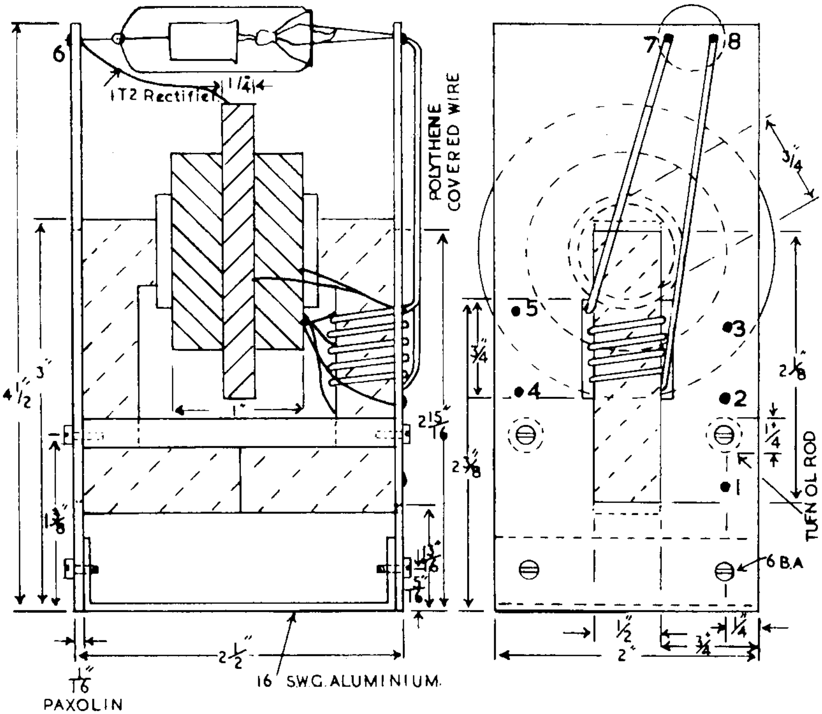
All capacitor values in µF except where otherwise shown

VAD/426·1

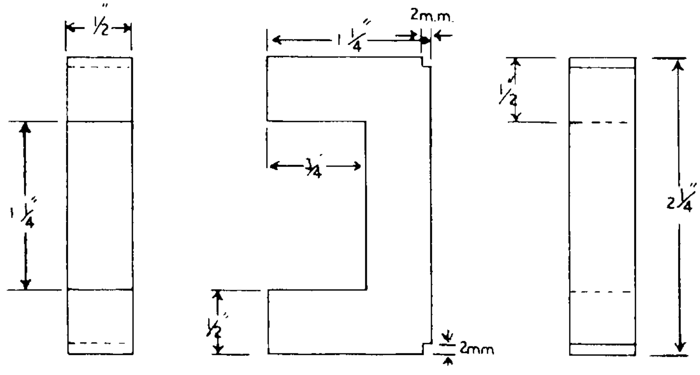

VAD/426·2
REGULATION OF
E.H.T. SUPPLY.
D.C. OUTPUT VOLTAGE kV
0
2
4
6
8
10
12
14
10
20
30
40
50
100
200
300
400
500
1000
D.C. LOAD CURRENT µA.

VAD/426·3

LINE OUTPUT TRANSFORMER DETAILS



NEOSID DUST CORE TYPE U.1.



VAD/426·4

WAVEFORM OF GRID DRIVE OF 6CD6G