Data Book

BRIMAR

RADIO VALVES & TELETUBES

Standard Telephones and Cables Limited

FOOTSCRAY - KENT - ENGLAND

BRIMAR

RECEIVING VALVE

6AM6

APPLICATION REPORT VAD/508.2

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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} = —0·9 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.

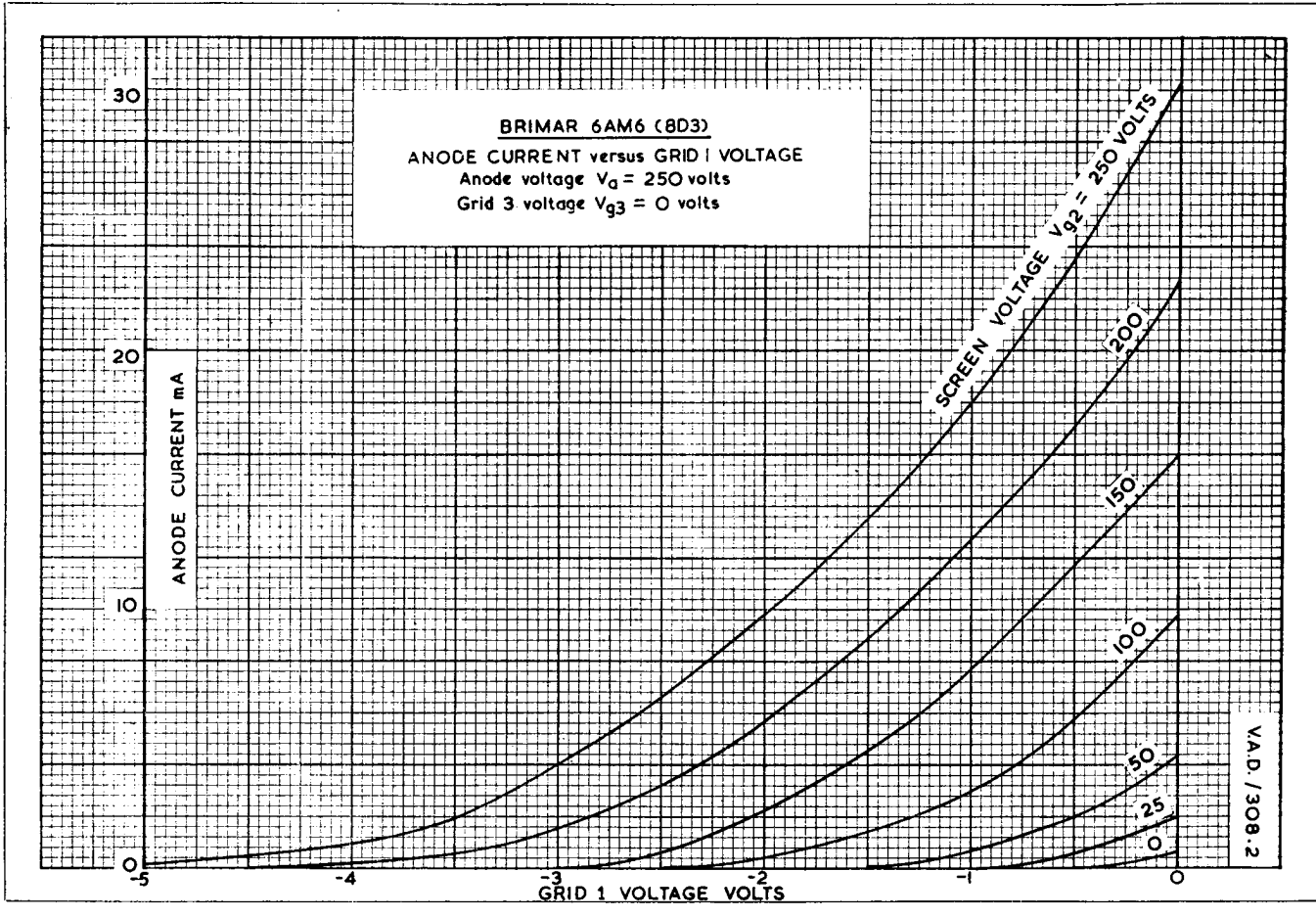
Operation as a Video Output Stage: The valve is very commonly employed as a wide band video amplifier in television receivers and curves are attached to this report showing this application. The curves plot the voltage gain against frequency with different values of output load capacity and different 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.

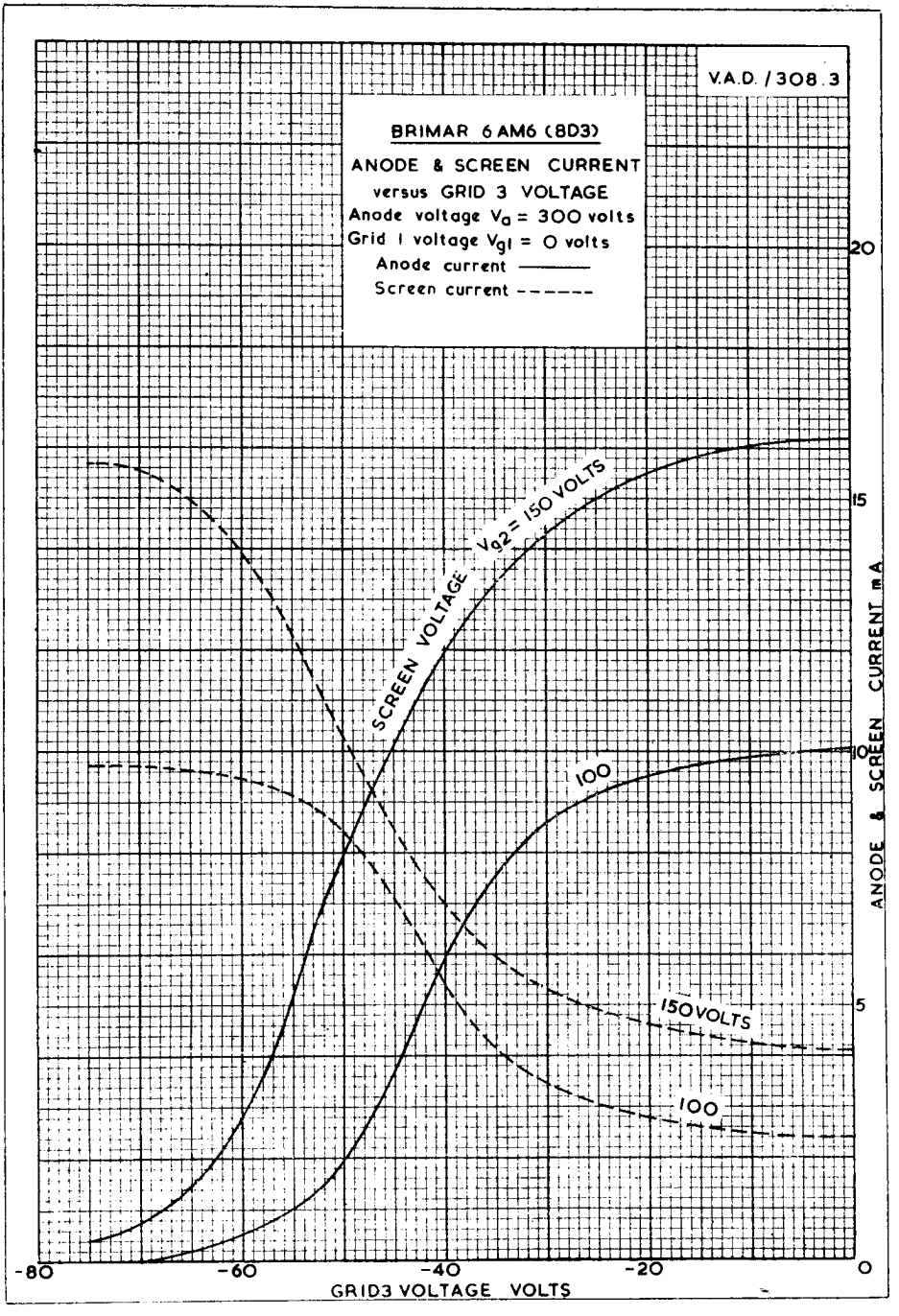
Curve No. 308·207 shows the voltage gain with three values of capacity 10, 15 and 20 pF for a load of 2·2K; Curves Nos. 308·208, 308·209 and 308·210 show corresponding curves for loads of 3·3, 4·7 and 6·8K. In the case of the latter the response cannot be compensated for a capacity of greater than 15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

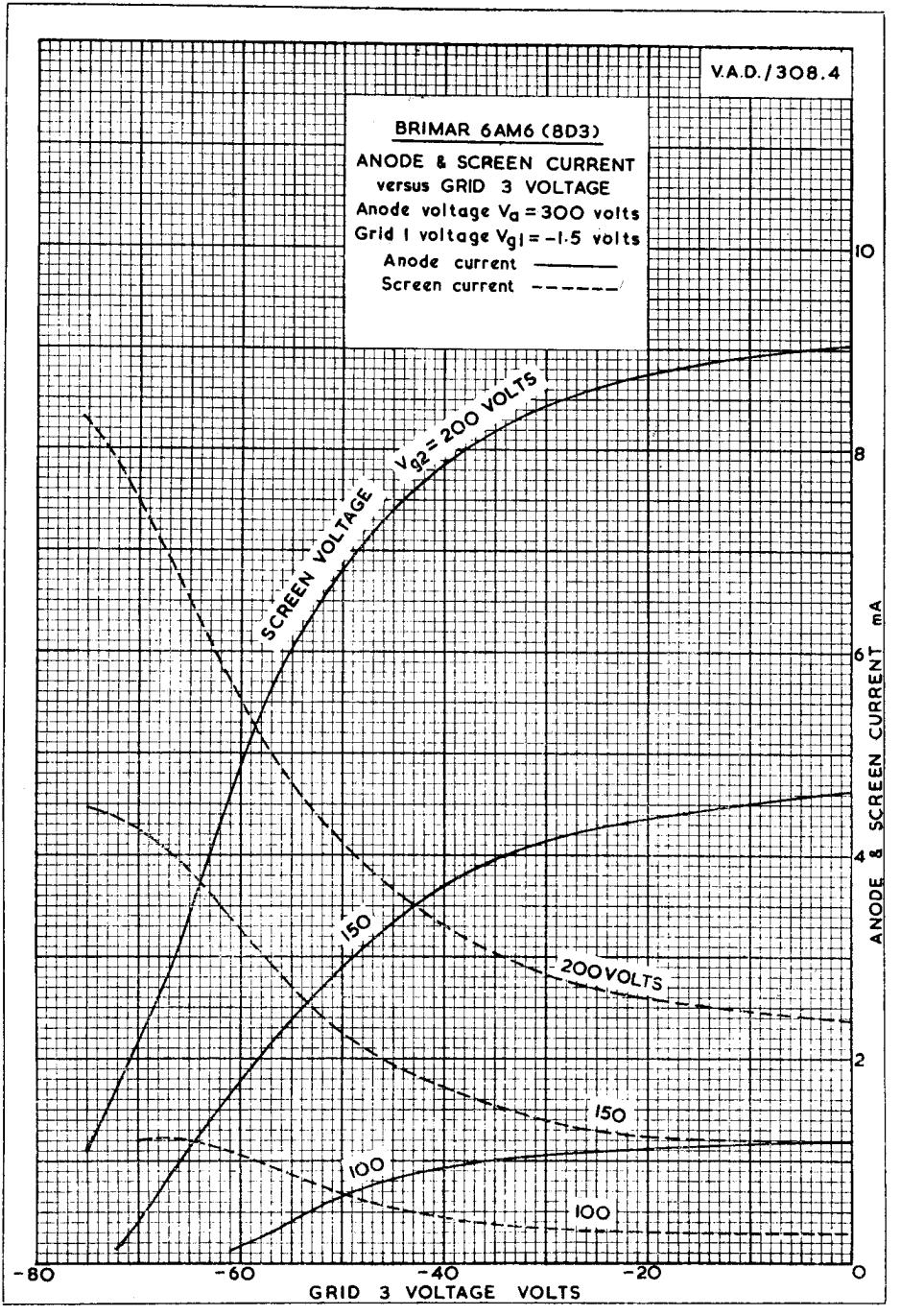
It is quite common practice when this valve is used as a video amplifier to obtain extra top lift by using a small value of cathode by-pass condenser or no condenser at all giving negative feed back at the lower frequencies, this practice will reduce the voltage gain shown in the curves by a factor of 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.

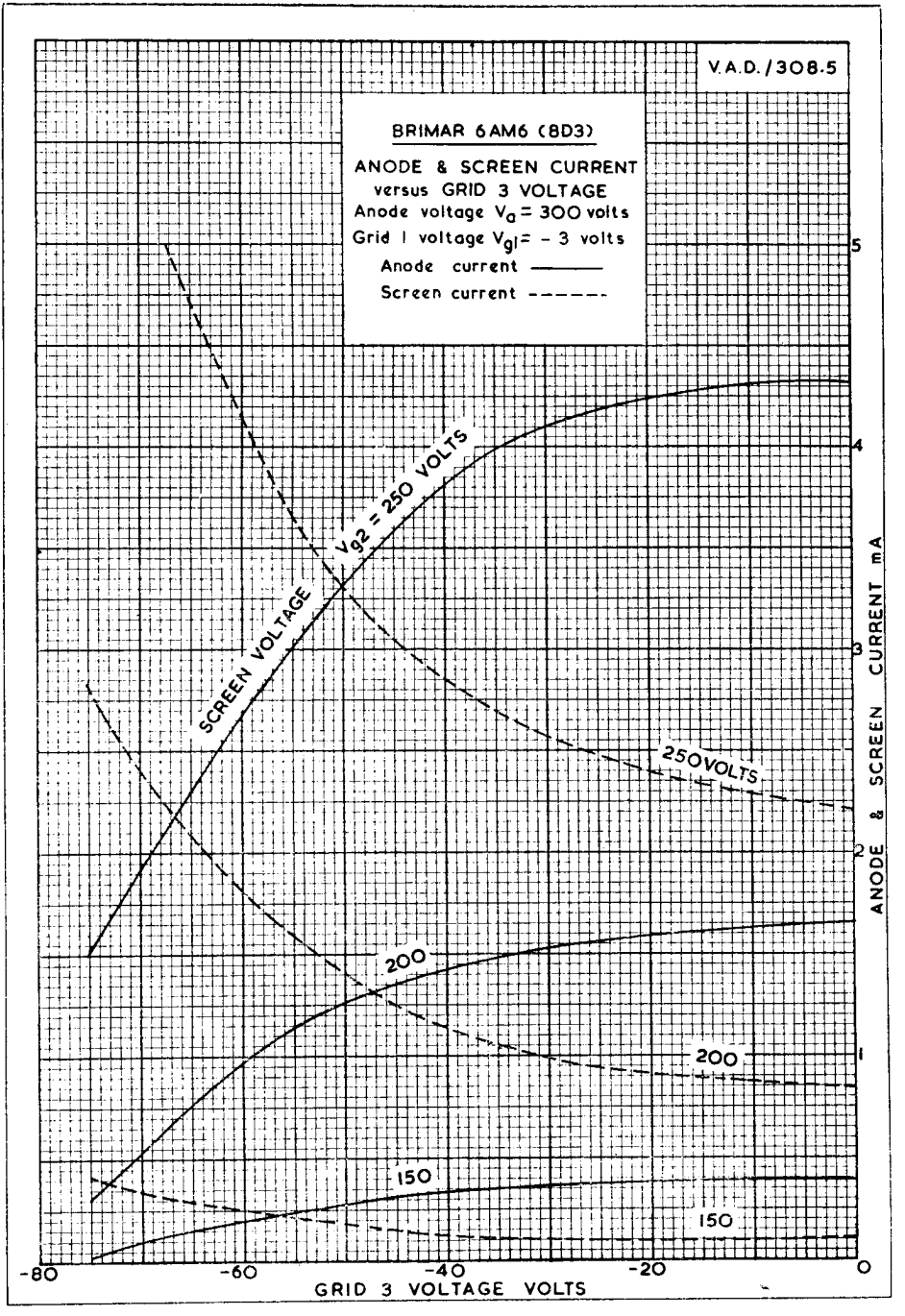
Operation as a Frequency Changer: Due to the high slope of the valve and its short grid base, it may be very successfully employed as a frequency changer at frequencies up to about 150 Mc/s. It is recommended that grid or cathode injection be employed. The Curve No. 308·213 shows the conversion conductance, 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:

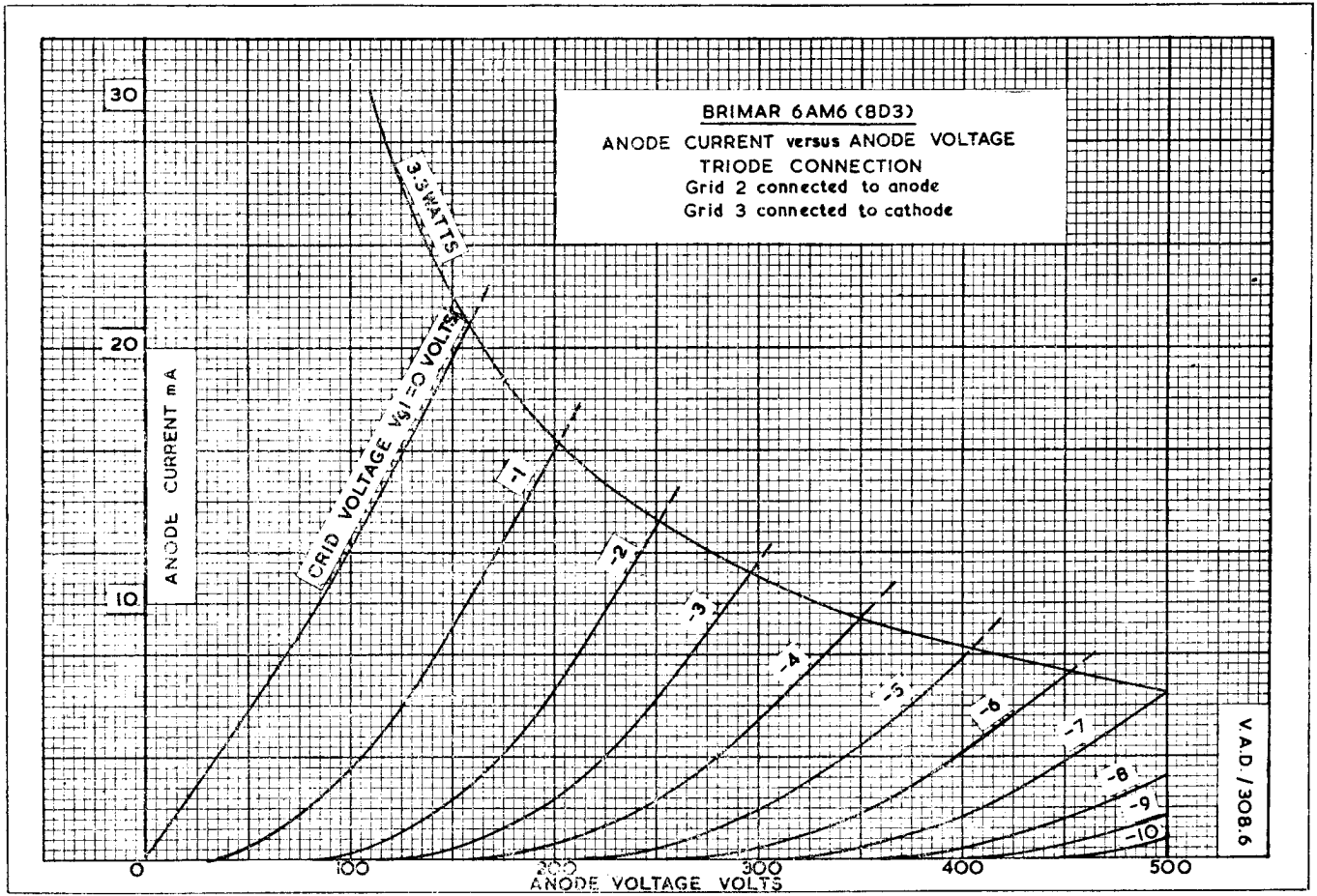
Anode Voltage	250 volts
Screen Voltage	250 volts
Autobias Resistor	1000 ohms
Anode Current	4·7 mA
Screen Current	1·2 mA
Peak Heterodyne Voltage	5 volts
Conversion Conductance	2·3 mA/V
Equivalent Noise Resistance	4500 ohms

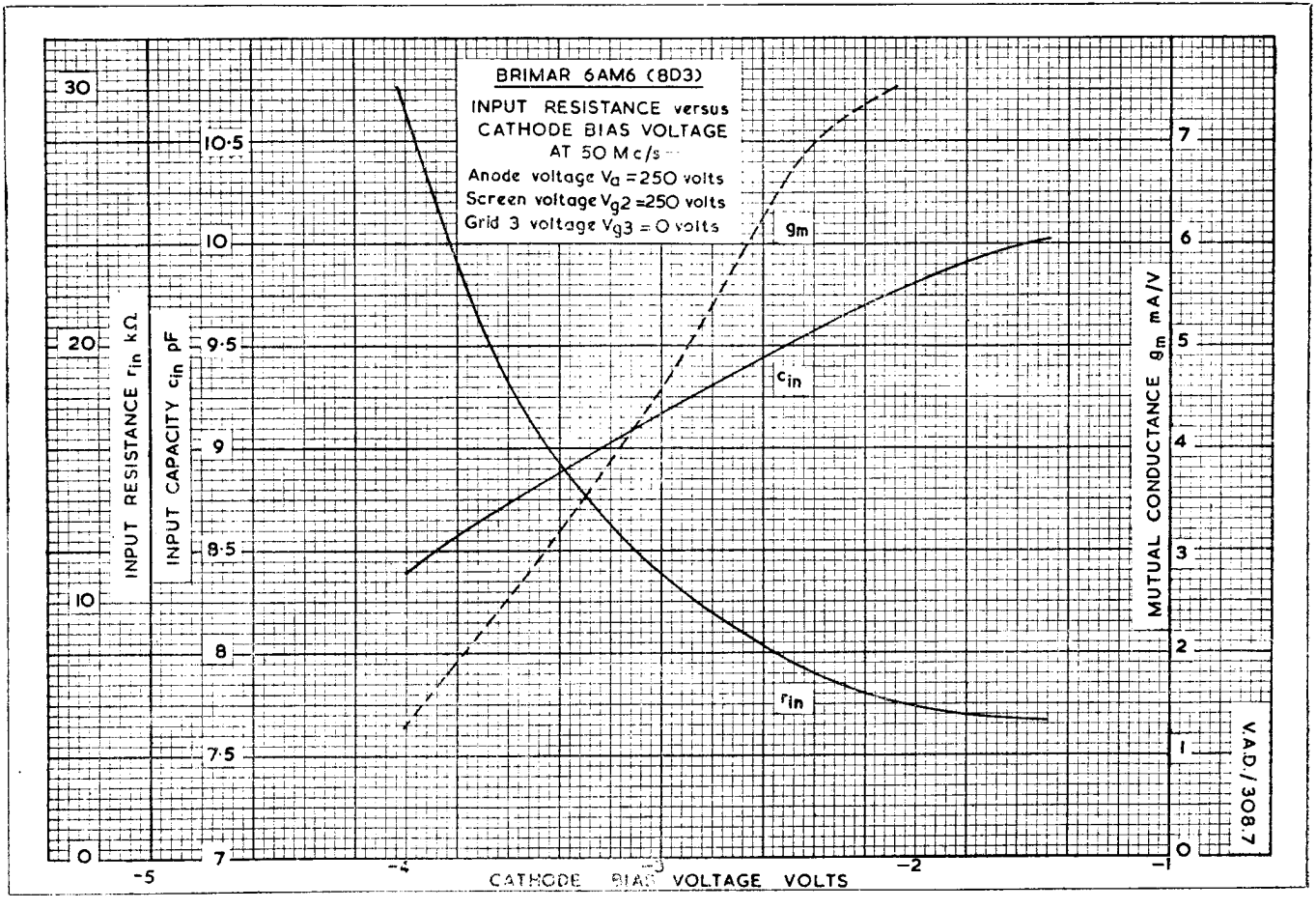

BRIMAR 6AM6 (8D3)
ANODE CURRENT versus GRID 1 VOLTAGE
Anode voltage V_a = 250 volts
Grid 3 voltage V_{g3} = 0 volts
ANODE CURRENT mA
30
20
10
0
-5
-4
-3
-2
-1
0
GRID 1 VOLTAGE VOLTS
SCREEN VOLTAGE V_{g2} = 250 VOLTS
200
150
100
50
25
0
V.A.D./308.2

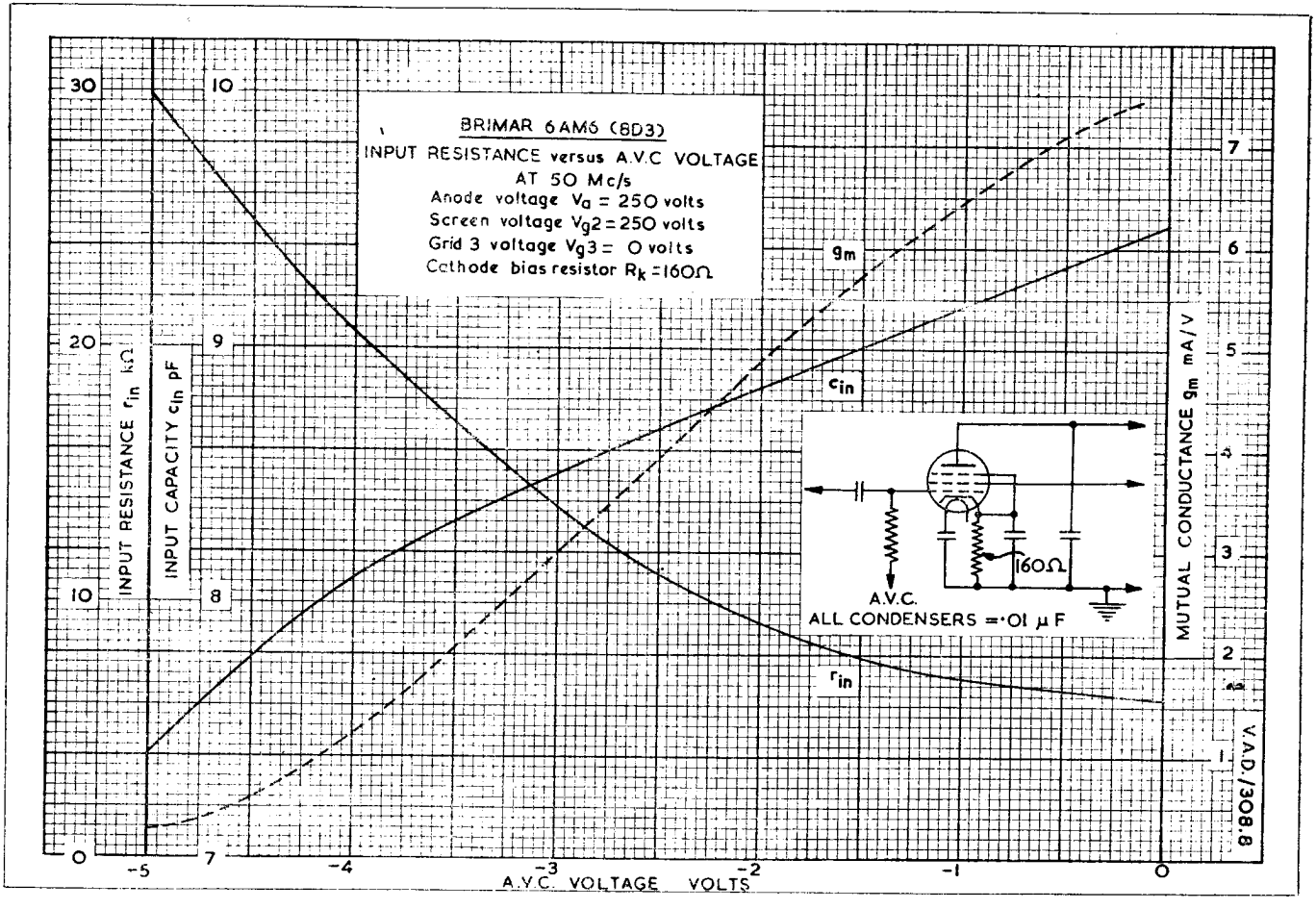

V.A.D. / 308.3
BRIMAR 6AM6 (8D3)
ANODE & SCREEN CURRENT
versus GRID 3 VOLTAGE
Anode voltage V_a = 300 volts
Grid 1 voltage V_{g1} = 0 volts
Anode current
Screen current
SCREEN VOLTAGE V_{g2} = 150 VOLTS
100
150 VOLTS
100
20
15
10
5
0
-80
-60
-40
-20
0
GRID3 VOLTAGE VOLTS
ANODE & SCREEN CURRENT mA

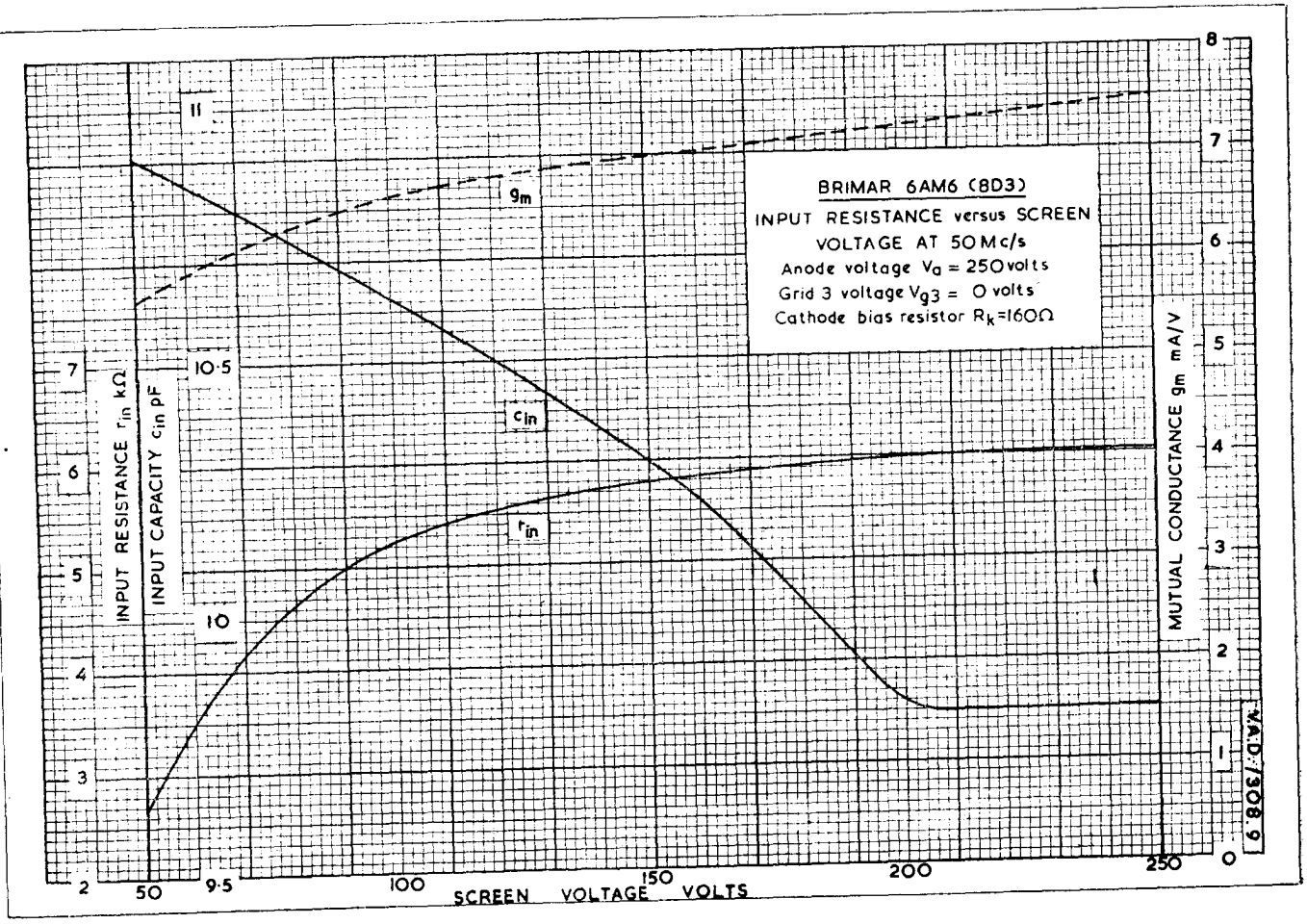

V.A.D./308.4
BRIMAR 6AM6 (8D3)
ANODE & SCREEN CURRENT
versus GRID 3 VOLTAGE
Anode voltage V_a = 300 volts
Grid 1 voltage V_{g1} = -1.5 volts
Anode current
Screen current
V_{g2} = 200 VOLTS
SCREEN VOLTAGE
150
200 VOLTS
150
100
100
10
8
6
4
2
0
-80
-60
-40
-20
GRID 3 VOLTAGE VOLTS
ANODE & SCREEN CURRENT mA

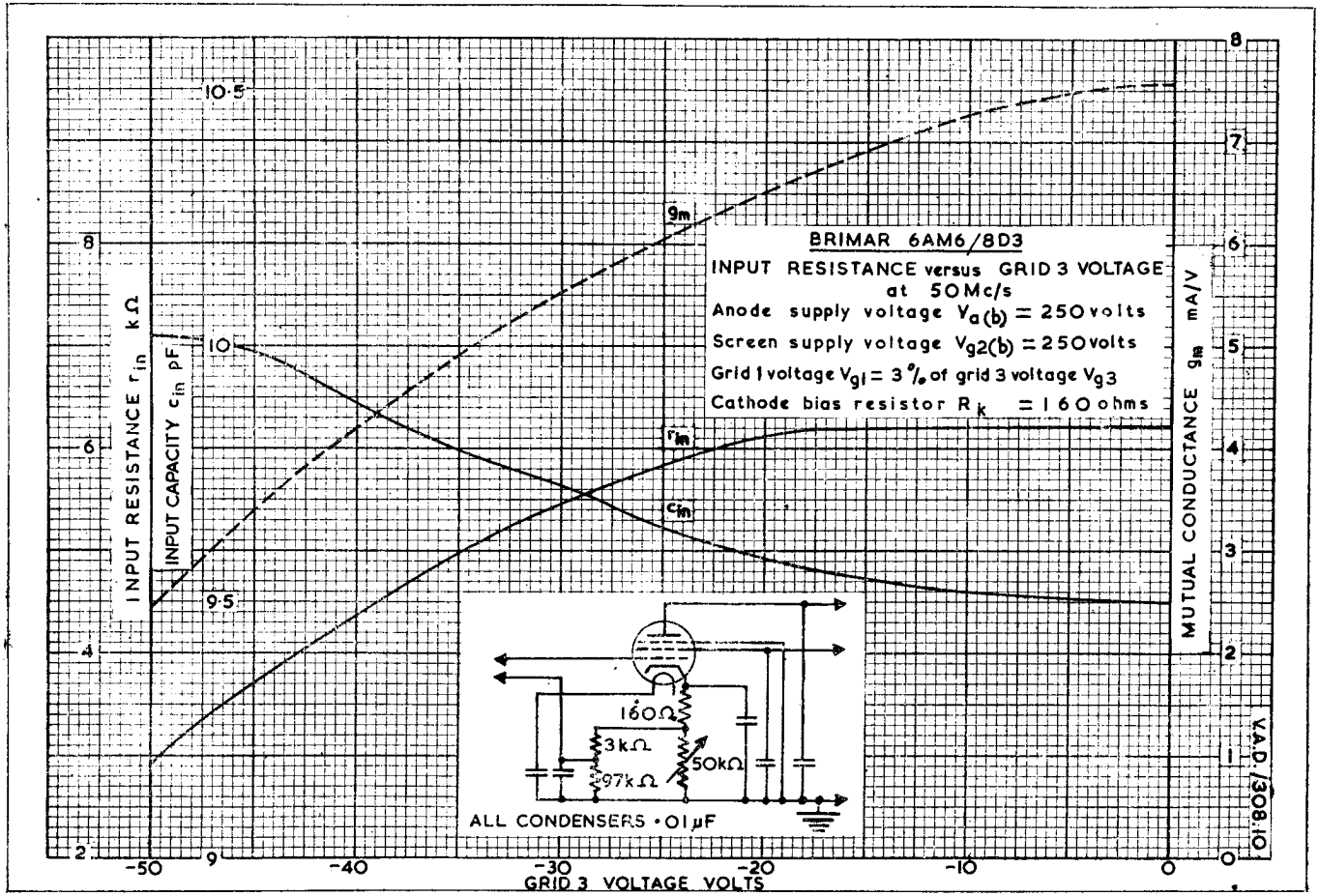

V.A.D./308.5
BRIMAR 6AM6 (8D3)
ANODE & SCREEN CURRENT
versus GRID 3 VOLTAGE
Anode voltage V_a = 300 volts
Grid 1 voltage V_{g1} = - 3 volts
Anode current
Screen current
SCREEN VOLTAGE
V_{g2} = 250 VOLTS
250VOLTS
200
200
150
150
-80
-60
-40
-20
0
GRID 3 VOLTAGE VOLTS
1
2
3
4
5
ANODE & SCREEN CURRENT mA

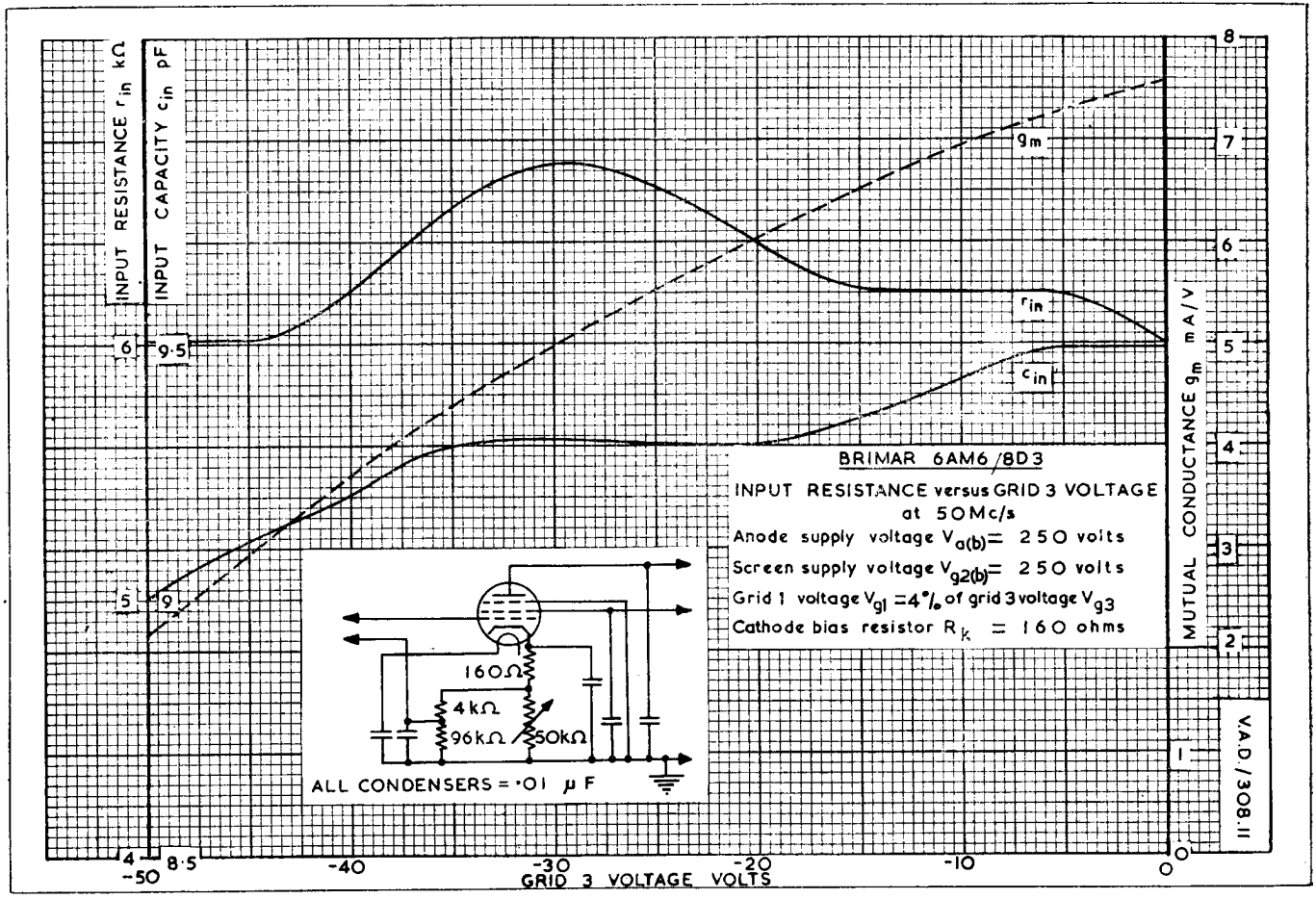

BRIMAR 6AM6 (8D3)
ANODE CURRENT versus ANODE VOLTAGE
TRIODE CONNECTION
Grid 2 connected to anode
Grid 3 connected to cathode
30
20
10
ANODE CURRENT mA
3·3 WATTS
GRID VOLTAGE Vg1 = 0 VOLTS
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
V.A.D./308.6

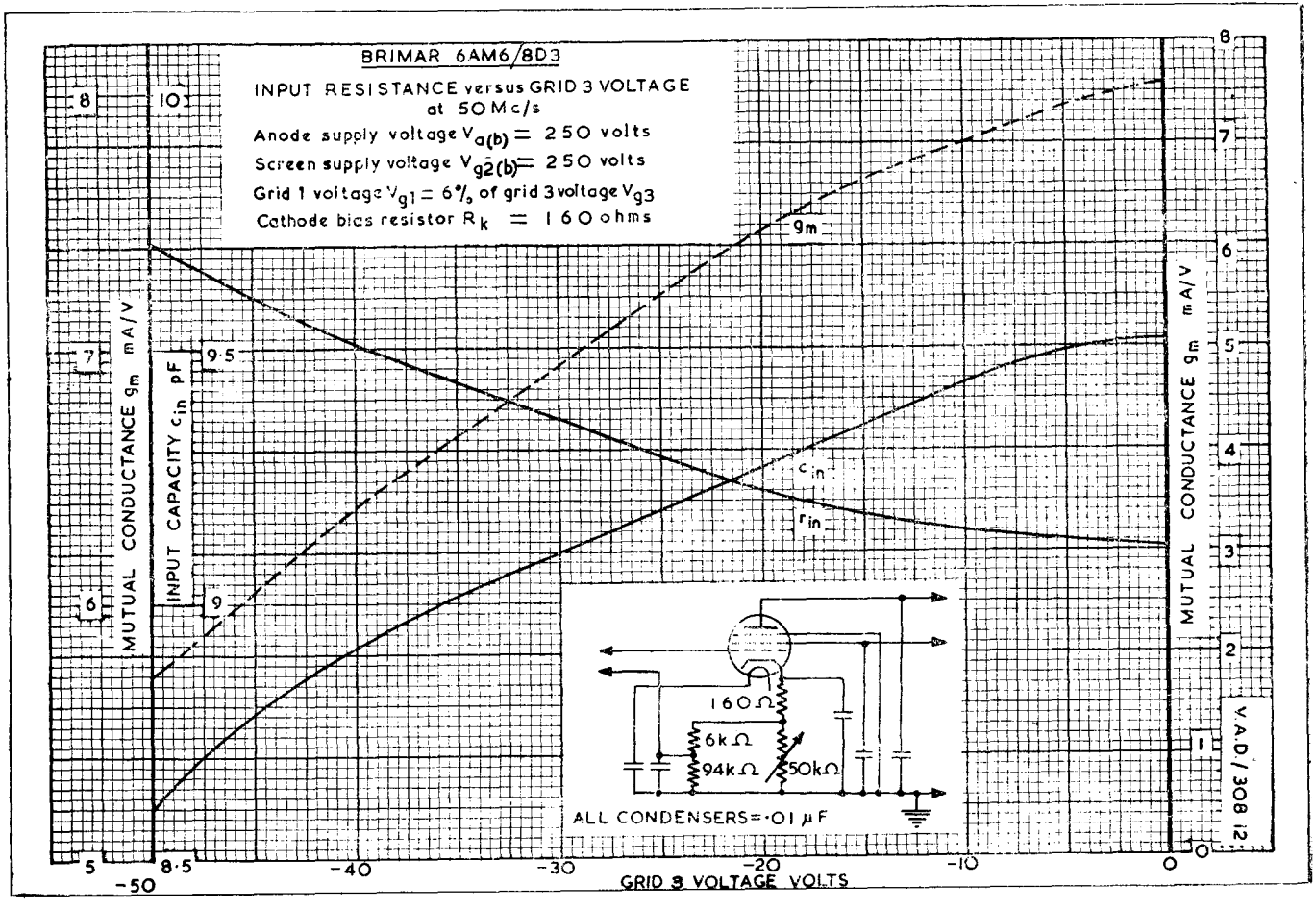

BRIMAR 6AM6 (8D3)
INPUT RESISTANCE versus
CATHODE BIAS VOLTAGE
AT 50 Mc/s
Anode voltage V_a = 250 volts
Screen voltage V_{g2} = 250 volts
Grid 3 voltage V_{g3} = 0 volts
gm
c_{in}
r_{in}
INPUT RESISTANCE r_{in} kΩ
INPUT CAPACITY c_{in} pF
MUTUAL CONDUCTANCE g_m mA/V
CATHODE BIAS VOLTAGE VOLTS
30
20
10
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./3087

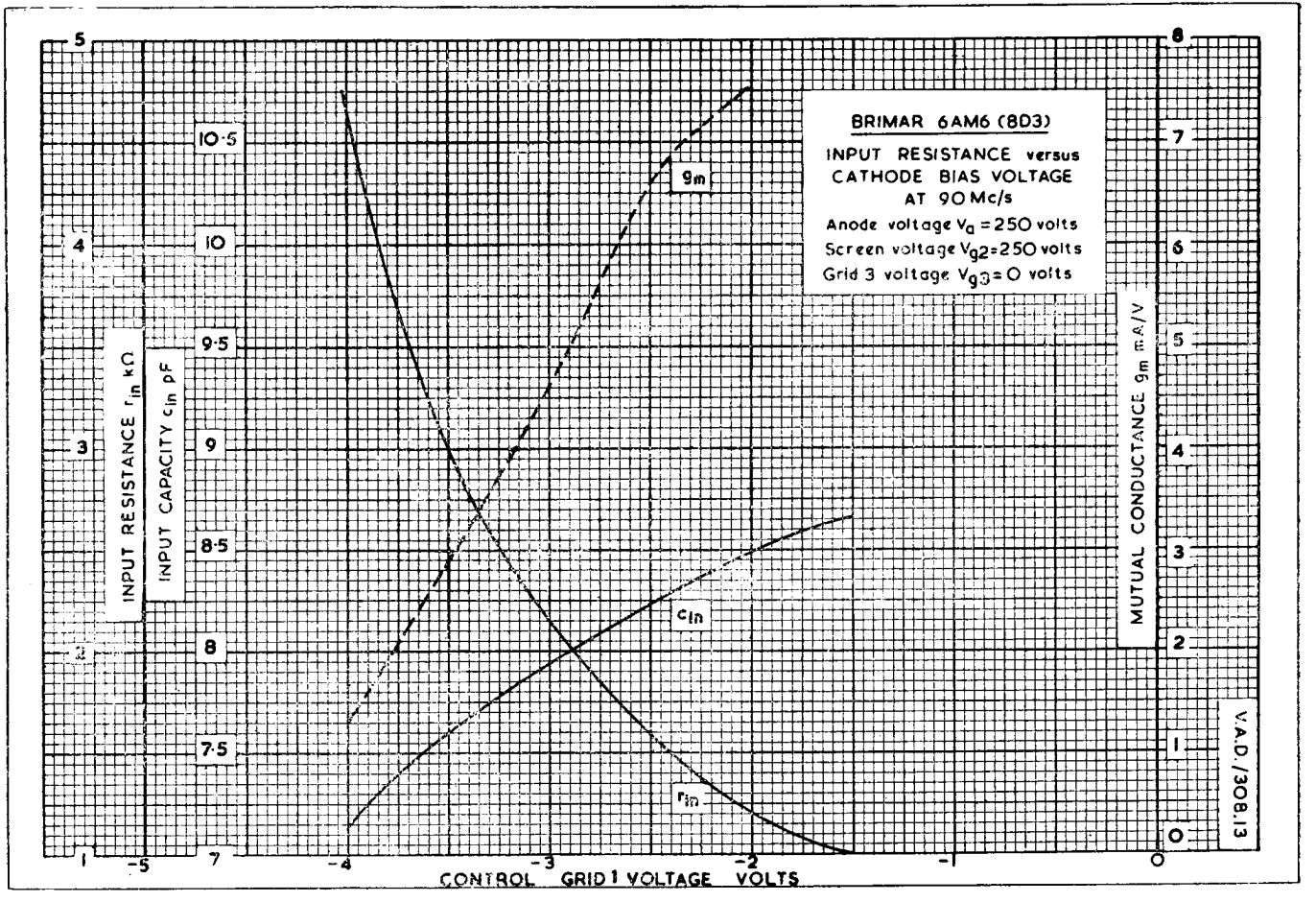

BRIMAR 6AM6 (8D3)
INPUT RESISTANCE versus A.V.C VOLTAGE
AT 50 Mc/s
Anode voltage V_a = 250 volts
Screen voltage V_{g2} = 250 volts
Grid 3 voltage V_{g3} = 0 volts
Cathode bias resistor R_k = 160Ω
g_m
c_{in}
r_{in}
160Ω
A.V.C.
ALL CONDENSERS = ·01 μF
INPUT RESISTANCE r_{in} kΩ
INPUT CAPACITY c_{in} pF
MUTUAL CONDUCTANCE g_m mA/V
A.V.C. VOLTAGE VOLTS
30
20
10
0
10
9
8
7
7
6
5
4
3
2
1
0
-5
-4
-3
-2
-1
0
V.A.D./3088

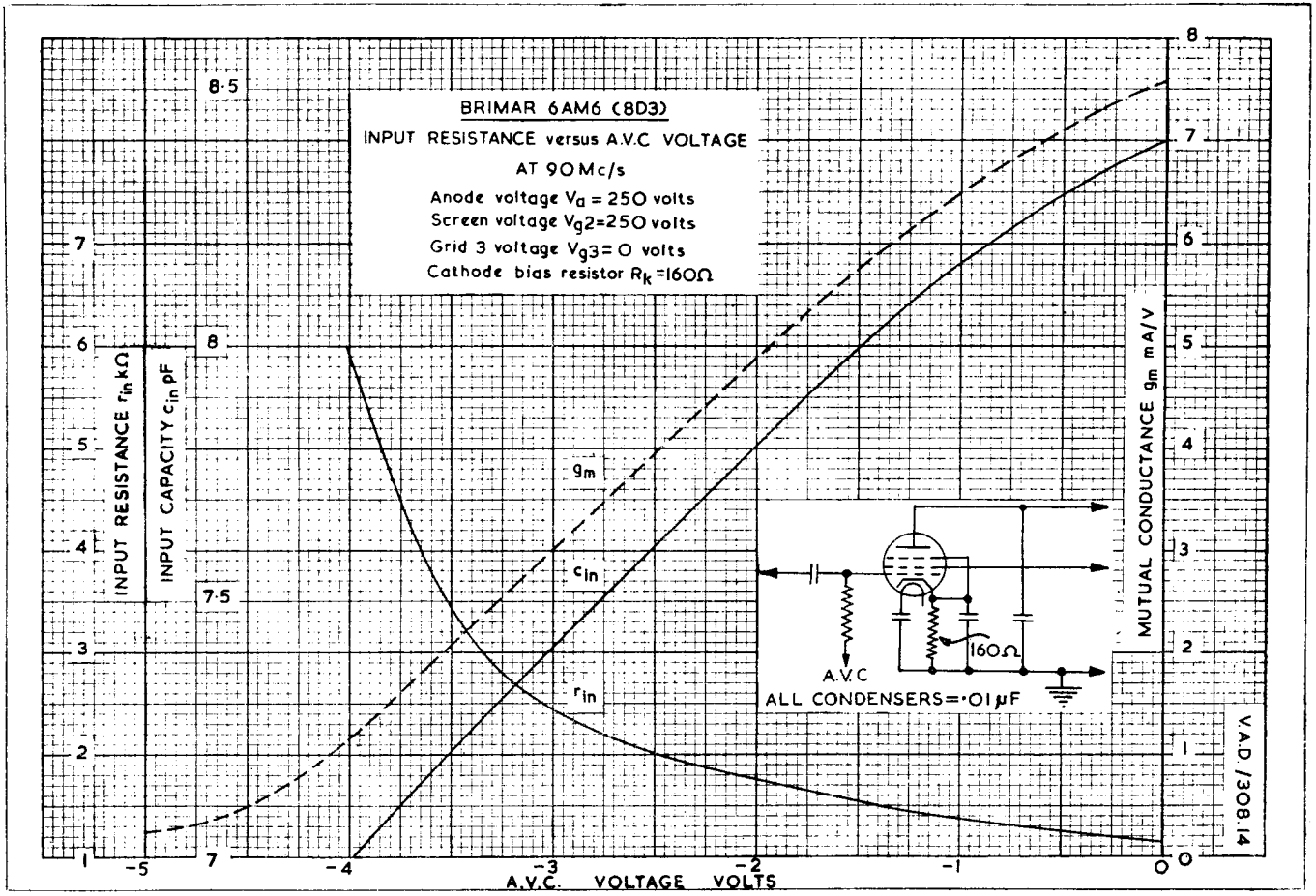

BRIMAR 6AM6 (8D3)
INPUT RESISTANCE versus SCREEN VOLTAGE AT 50 Mc/s
Anode voltage V_a = 250 volts
Grid 3 voltage V_{g3} = 0 volts
Cathode bias resistor R_k = 160Ω
g_m
c_{in}
r_{in}
11
10·5
10
9·5
INPUT RESISTANCE r_{in} kΩ
INPUT CAPACITY c_{in} pF
MUTUAL CONDUCTANCE g_m mA/V
SCREEN VOLTAGE VOLTS
50
100
150
200
250
2
3
4
5
6
7
0
1
2
3
4
5
6
7
8
9
MAD/3/808

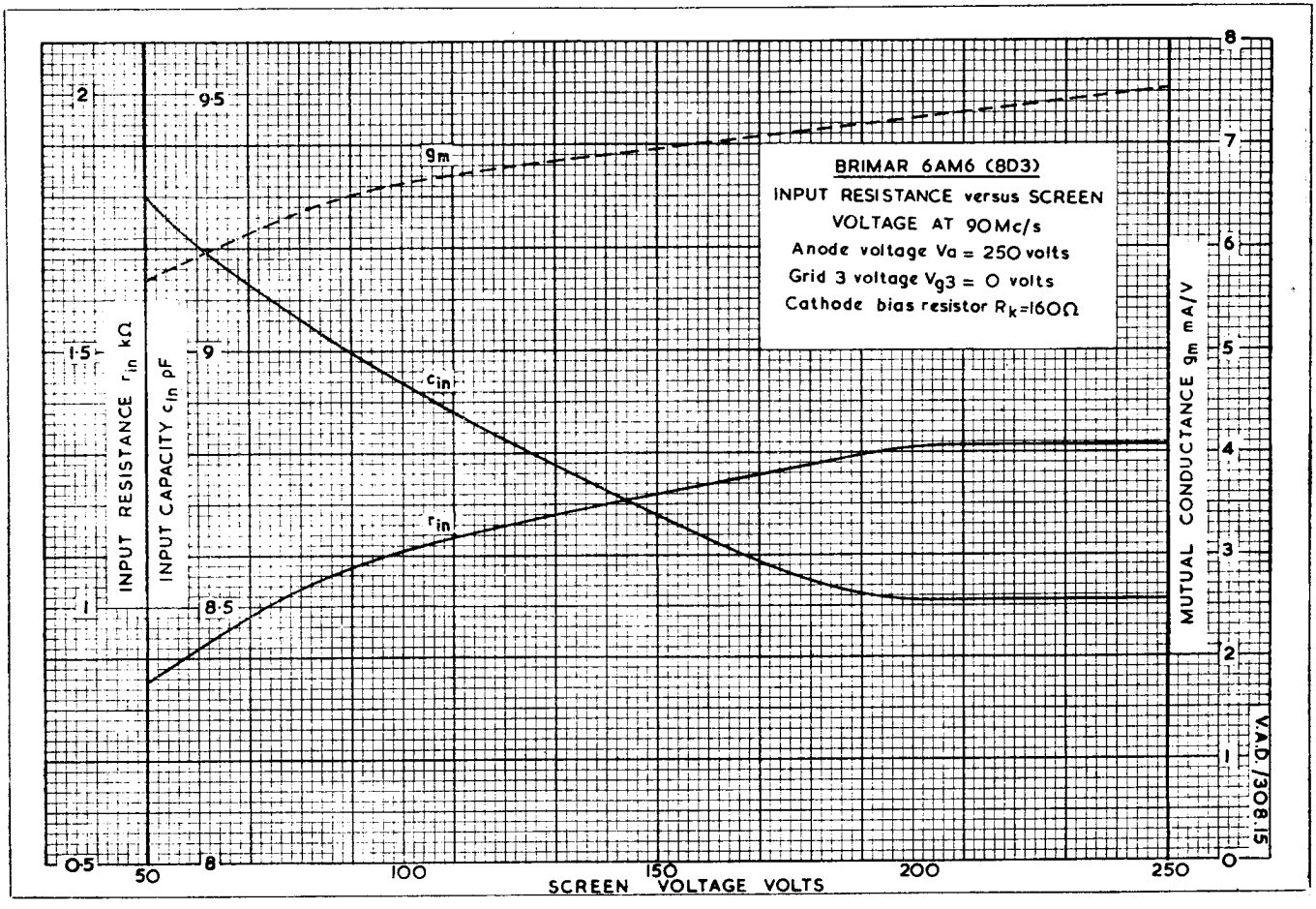

BRIMAR 6AM6/8D3
INPUT RESISTANCE versus GRID 3 VOLTAGE
at 50Mc/s
Anode supply voltage $V_{a(b)}$ = 250 volts
Screen supply voltage $V_{g2(b)}$ = 250 volts
Grid 1 voltage V_{g1} = 3% of grid 3 voltage V_{g3}
Cathode bias resistor R_k = 160 ohms
INPUT RESISTANCE r_{in} kΩ
INPUT CAPACITY c_{in} pF
MUTUAL CONDUCTANCE g_m mA/V
GRID 3 VOLTAGE VOLTS
g_m
r_{in}
c_{in}
160Ω
3kΩ
97kΩ
50kΩ
ALL CONDENSERS ·01μF
VA.0/8030

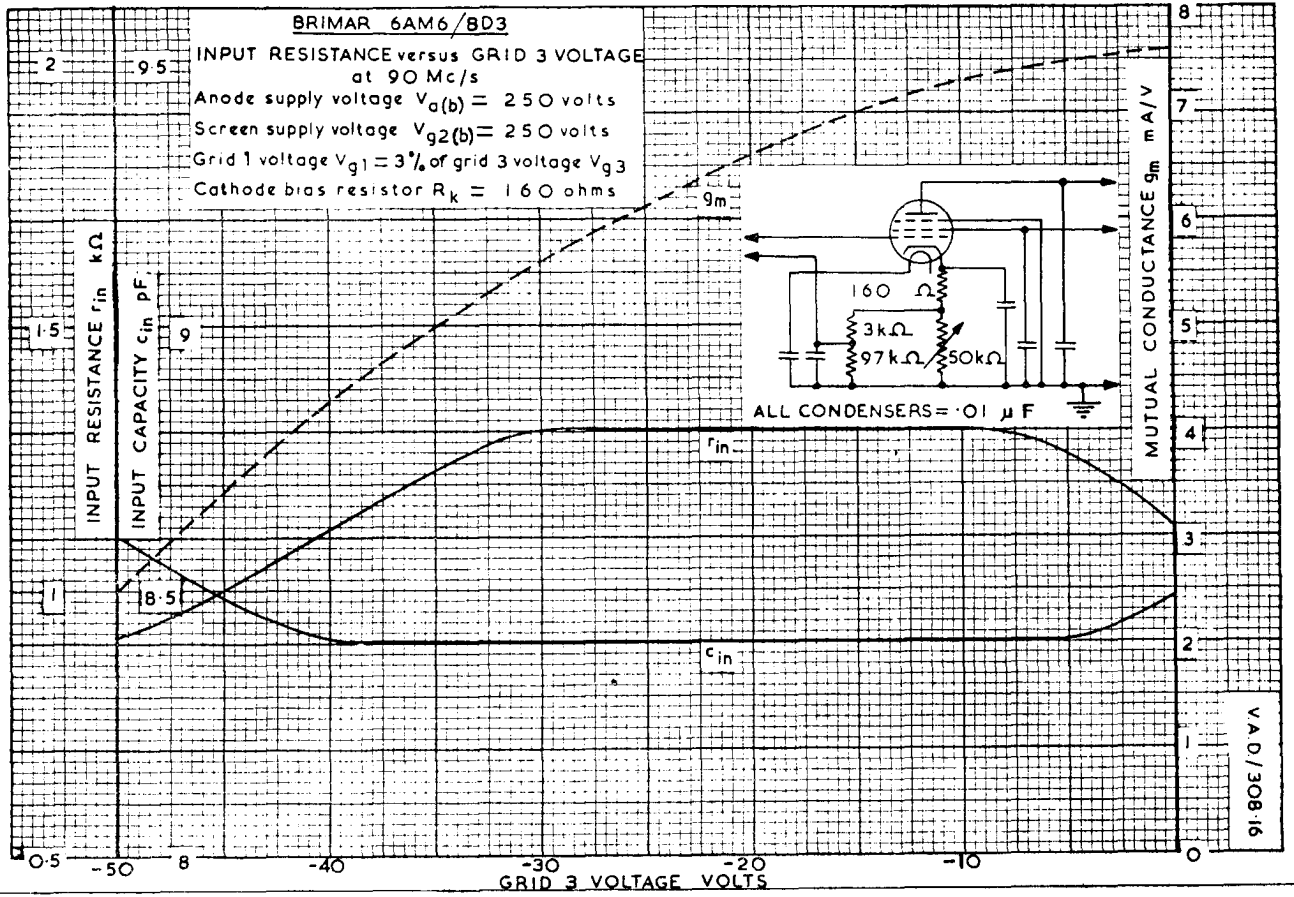

INPUT RESISTANCE r_{in} kΩ
INPUT CAPACITY c_{in} pF
MUTUAL CONDUCTANCE g_m mA/V
g_m
r_{in}
c_{in}
6
9·5
5
9
4
8·5
8
7
6
5
4
3
2
1
0
-50
-40
-30
-20
-10
0
GRID 3 VOLTAGE VOLTS
V.A.D./308.11
BRIMAR 6AM6/8D3
INPUT RESISTANCE versus GRID 3 VOLTAGE
at 50Mc/s
Anode supply voltage $V_{a(b)}$ = 250 volts
Screen 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
160Ω
4kΩ
96kΩ
50kΩ
ALL CONDENSERS = ·01 μF

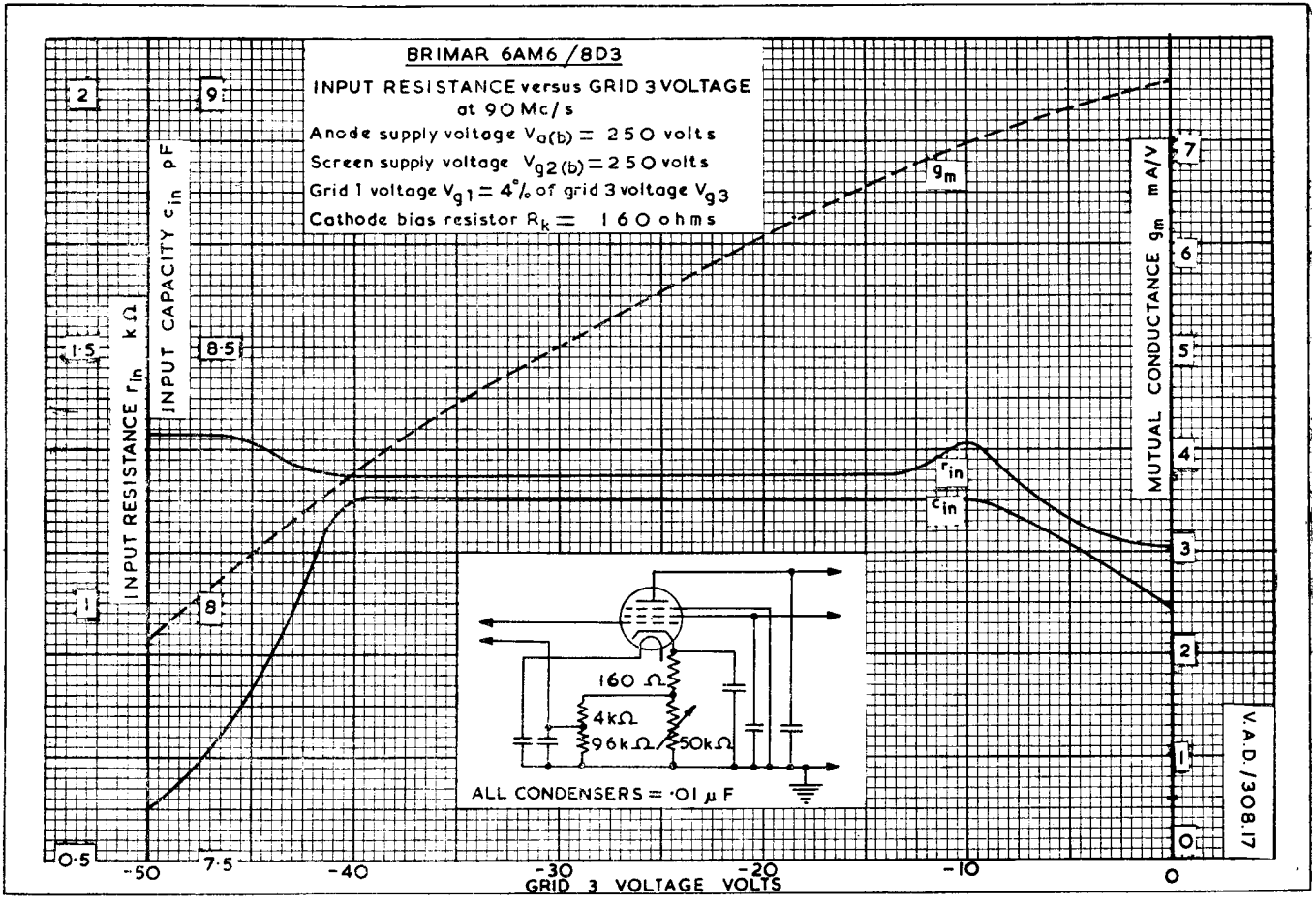

BRIMAR 6AM6/8D3
INPUT RESISTANCE versus GRID 3 VOLTAGE
at 50 Mc/s
Anode supply voltage $V_{a(b)}$ = 250 volts
Screen supply voltage $V_{g2(b)}$ = 250 volts
Grid 1 voltage V_{g1} = 6% of grid 3 voltage V_{g3}
Cathode bias resistor R_k = 160 ohms
MUTUAL CONDUCTANCE g_m mA/V
INPUT CAPACITY c_{in} pF
MUTUAL CONDUCTANCE g_m mA/V
g_m
c_{in}
r_{in}
160Ω
6kΩ
94kΩ
50kΩ
ALL CONDENSERS=·01 μF
GRID 3 VOLTAGE VOLTS
-50
-40
-30
-20
-10
0
V.A.D./308/12

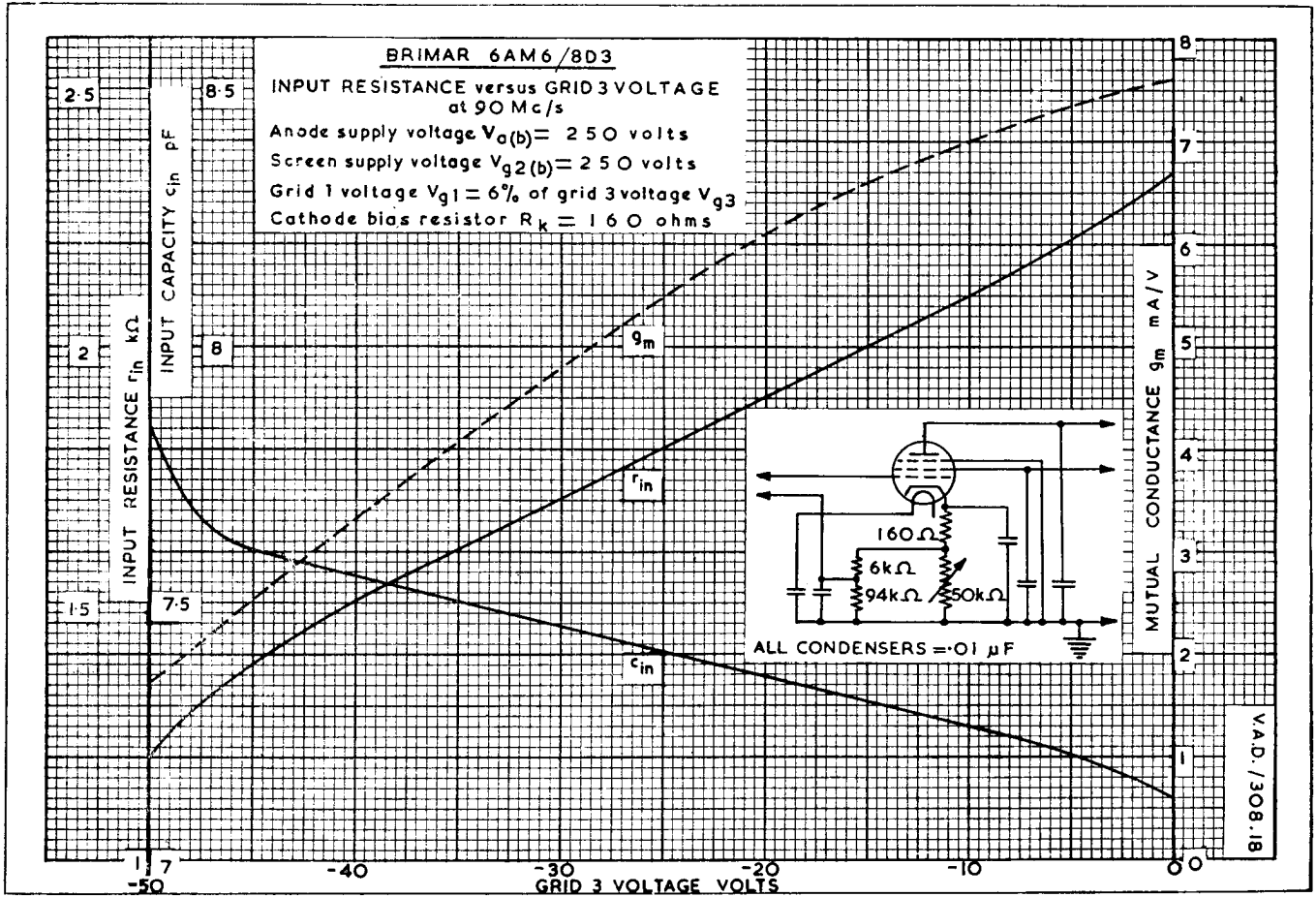

BRIMAR 6AM6 (8D3)
INPUT RESISTANCE versus
CATHODE BIAS VOLTAGE
AT 90 Mc/s
Anode voltage V_a = 250 volts
Screen voltage V_{g2} = 250 volts
Grid 3 voltage V_{g3} = 0 volts
INPUT RESISTANCE r_{in} kΩ
INPUT CAPACITY c_{in} pF
MUTUAL CONDUCTANCE g_m mA/V
g_m
c_{in}
r_{in}
CONTROL GRID 1 VOLTAGE VOLTS
V.A.D./308.13

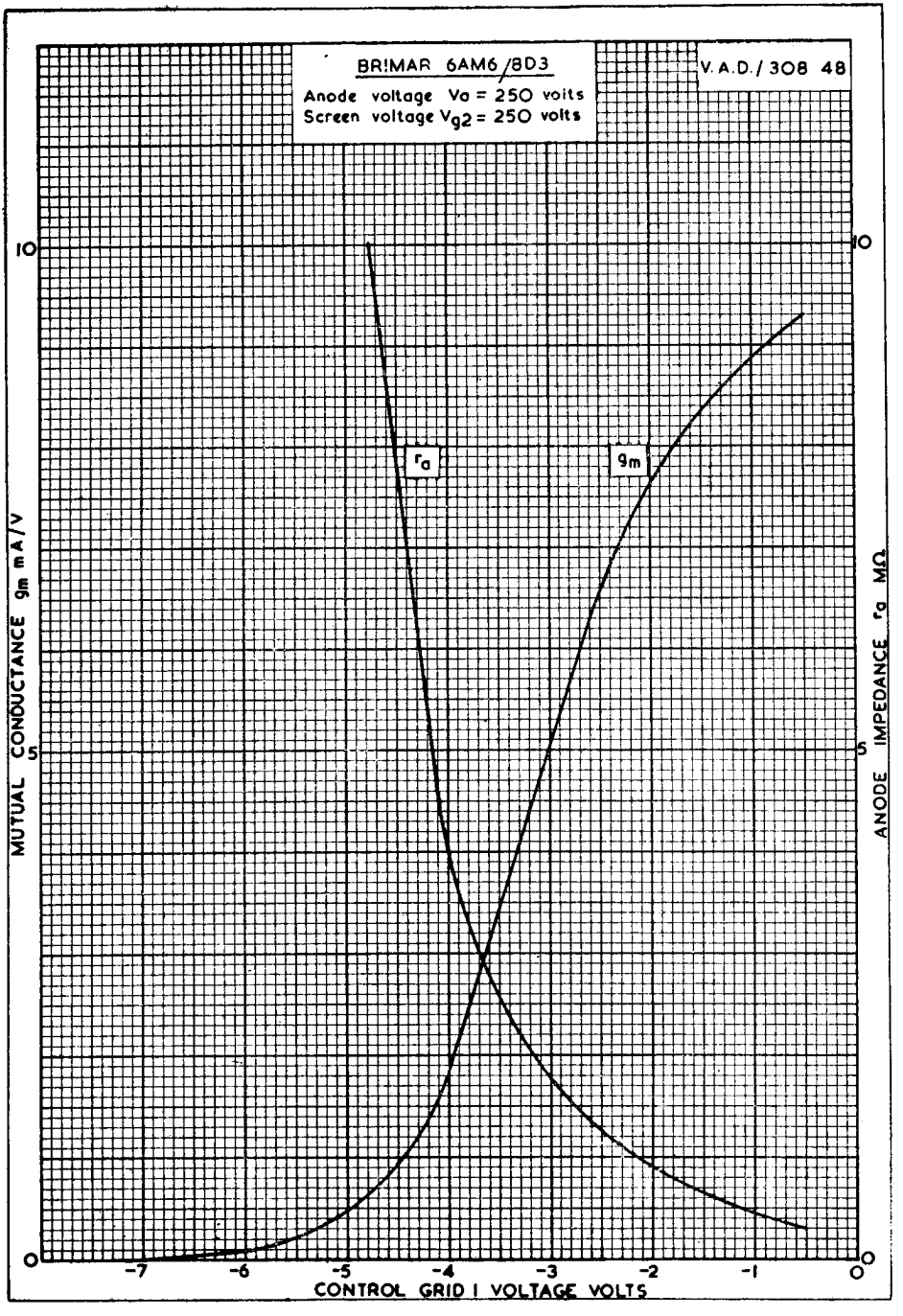

BRIMAR 6AM6 (8D3)
INPUT RESISTANCE versus A.V.C VOLTAGE
AT 90 Mc/s
Anode voltage V_a = 250 volts
Screen voltage V_{g2}=250 volts
Grid 3 voltage V_{g3}= 0 volts
Cathode bias resistor R_k=160Ω
INPUT RESISTANCE r_{in} kΩ
INPUT CAPACITY c_{in} pF
MUTUAL CONDUCTANCE g_m mA/V
A.V.C. VOLTAGE VOLTS
g_m
c_{in}
r_{in}
160Ω
A.V.C
ALL CONDENSERS=·01μF
V.A.D /308.14

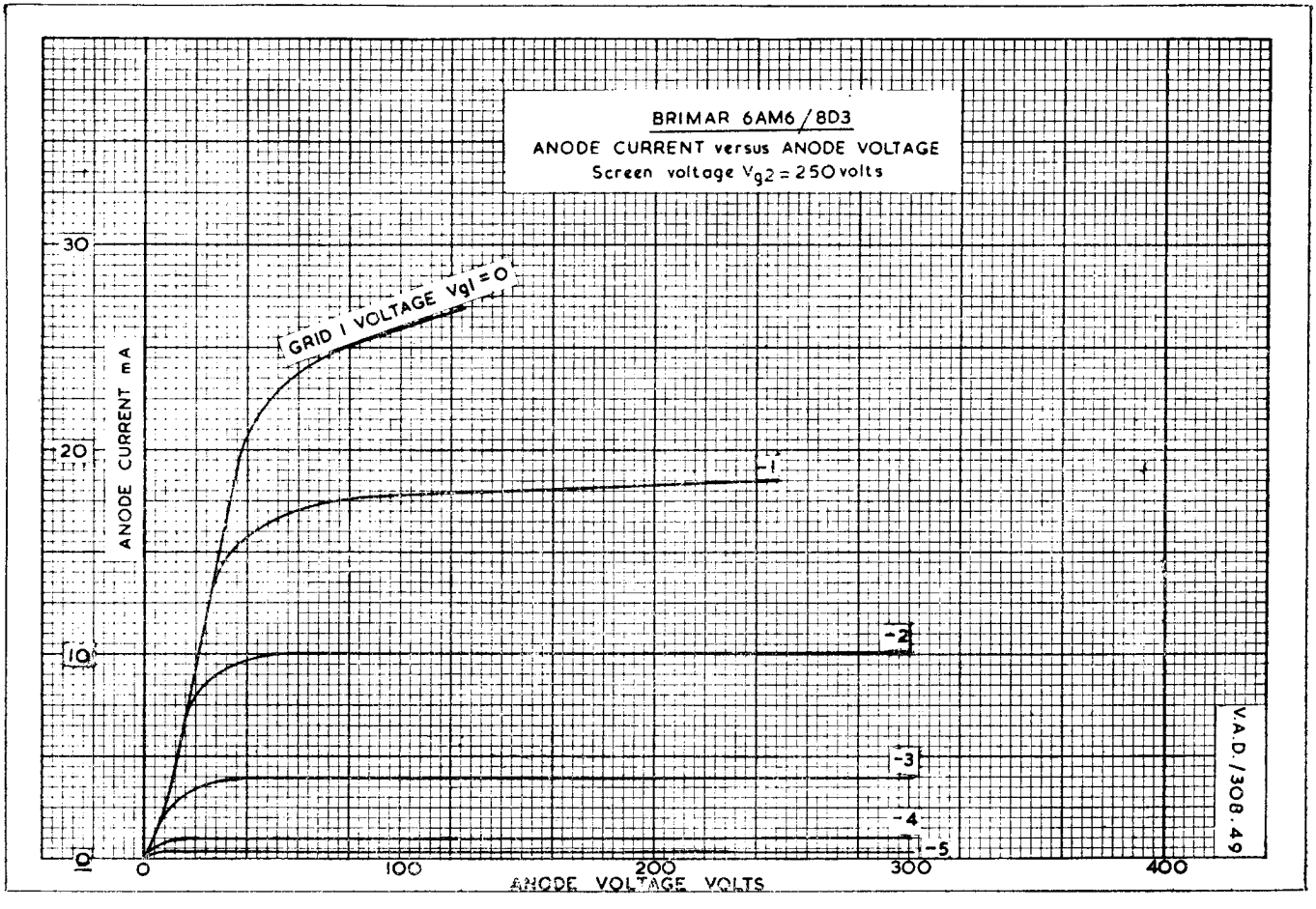

BRIMAR 6AM6 (8D3)
INPUT RESISTANCE versus SCREEN VOLTAGE AT 90Mc/s
Anode voltage Va = 250 volts
Grid 3 voltage Vg3 = 0 volts
Cathode bias resistor Rk=160Ω
gm
cin
rin
INPUT RESISTANCE rin kΩ
INPUT CAPACITY cin pF
MUTUAL CONDUCTANCE gm mA/V
SCREEN VOLTAGE VOLTS
2
1·5
1
0·5
9·5
9
8·5
8
8
7
6
5
4
3
2
1
0
50
100
150
200
250
V.A.D./308.15

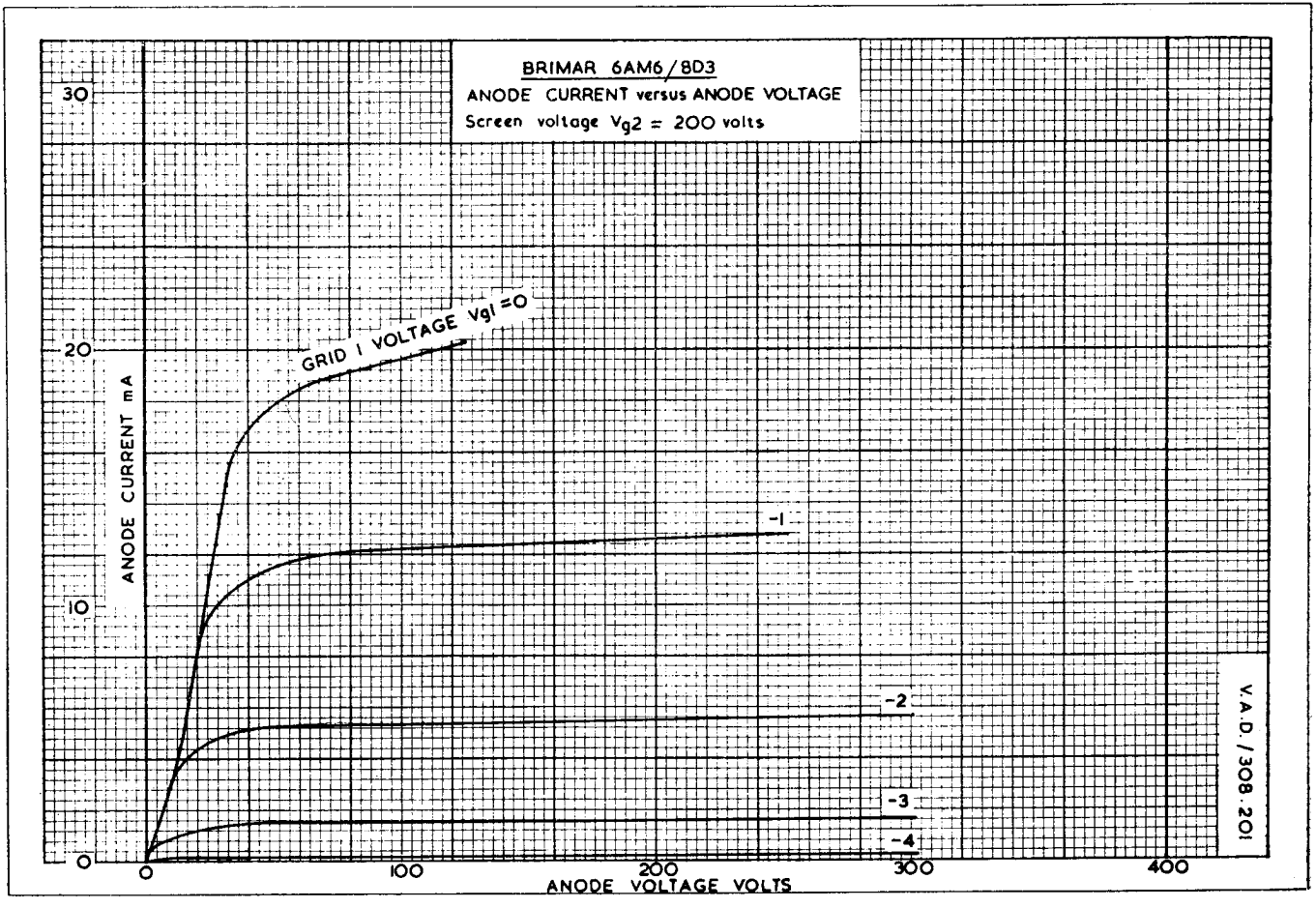

BRIMAR 6AM6/8D3
INPUT RESISTANCE versus GRID 3 VOLTAGE
at 90 Mc/s
Anode supply voltage $V_{a(b)}$ = 250 volts
Screen supply voltage $V_{g2(b)}$ = 250 volts
Grid 1 voltage V_{g1} = 3% of grid 3 voltage V_{g3}
Cathode bias resistor R_k = 160 ohms
INPUT RESISTANCE r_{in} kΩ
INPUT CAPACITY c_{in} pF
MUTUAL CONDUCTANCE g_m mA/V
2
1·5
1
9·5
9
8·5
8
7
6
5
4
3
2
1
0
0·5
g_m
r_{in}
c_{in}
160 Ω
3kΩ
97kΩ
50kΩ
ALL CONDENSERS = ·01 μF
-50
-40
-30
-20
-10
GRID 3 VOLTAGE VOLTS
V.A.D./308.16

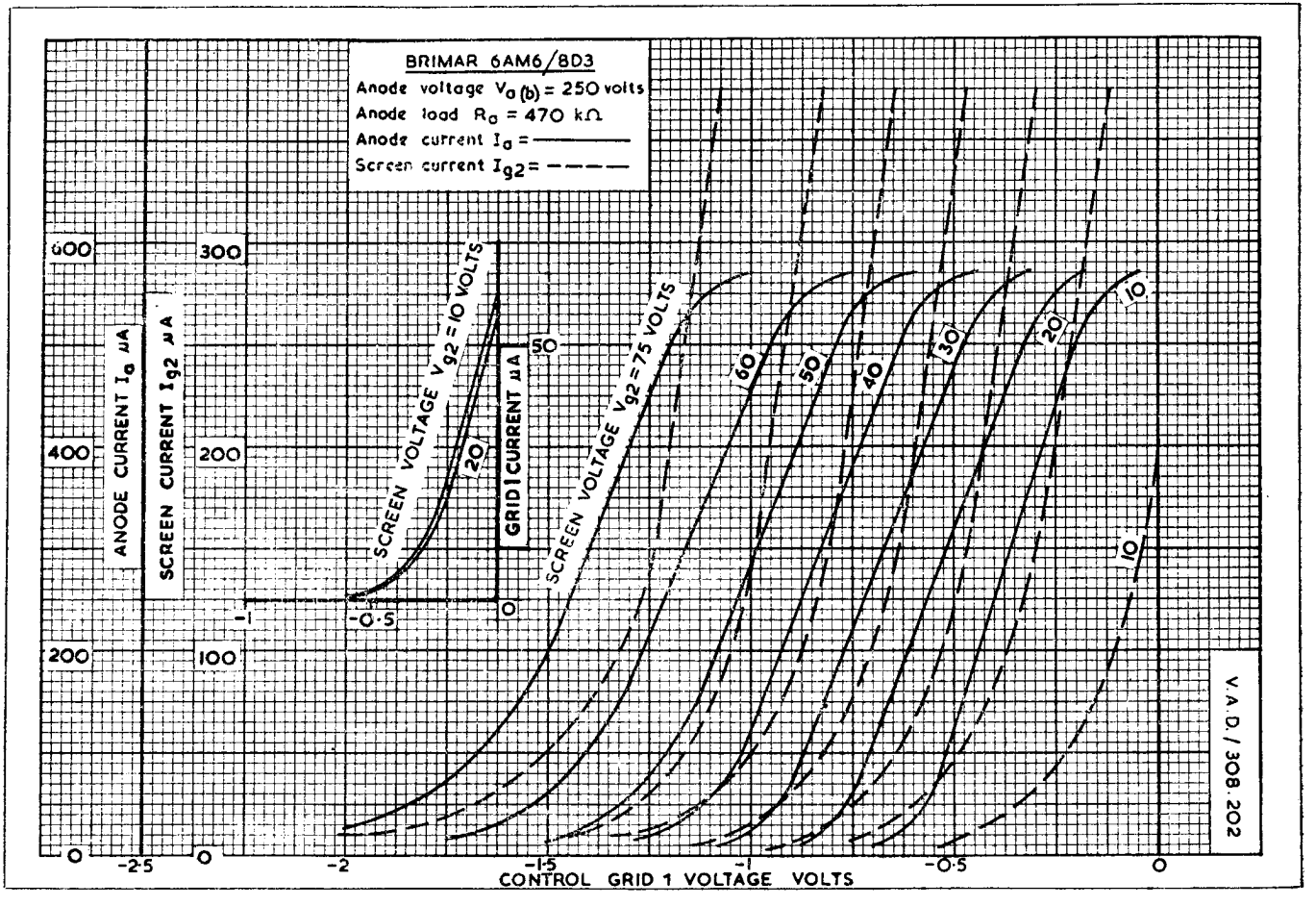

BRIMAR 6AM6 / 8D3
INPUT RESISTANCE versus GRID 3 VOLTAGE
at 90 Mc/s
Anode supply voltage $V_{a(b)}$ = 250 volts
Screen supply voltage $V_{g2(b)}$ = 250 volts
Grid 1 voltage V_{g1} = 4% of grid 3 voltage V_{g3}
Cathode bias resistor R_k = 160 ohms
INPUT RESISTANCE r_{in} kΩ
INPUT CAPACITY c_{in} pF
MUTUAL 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

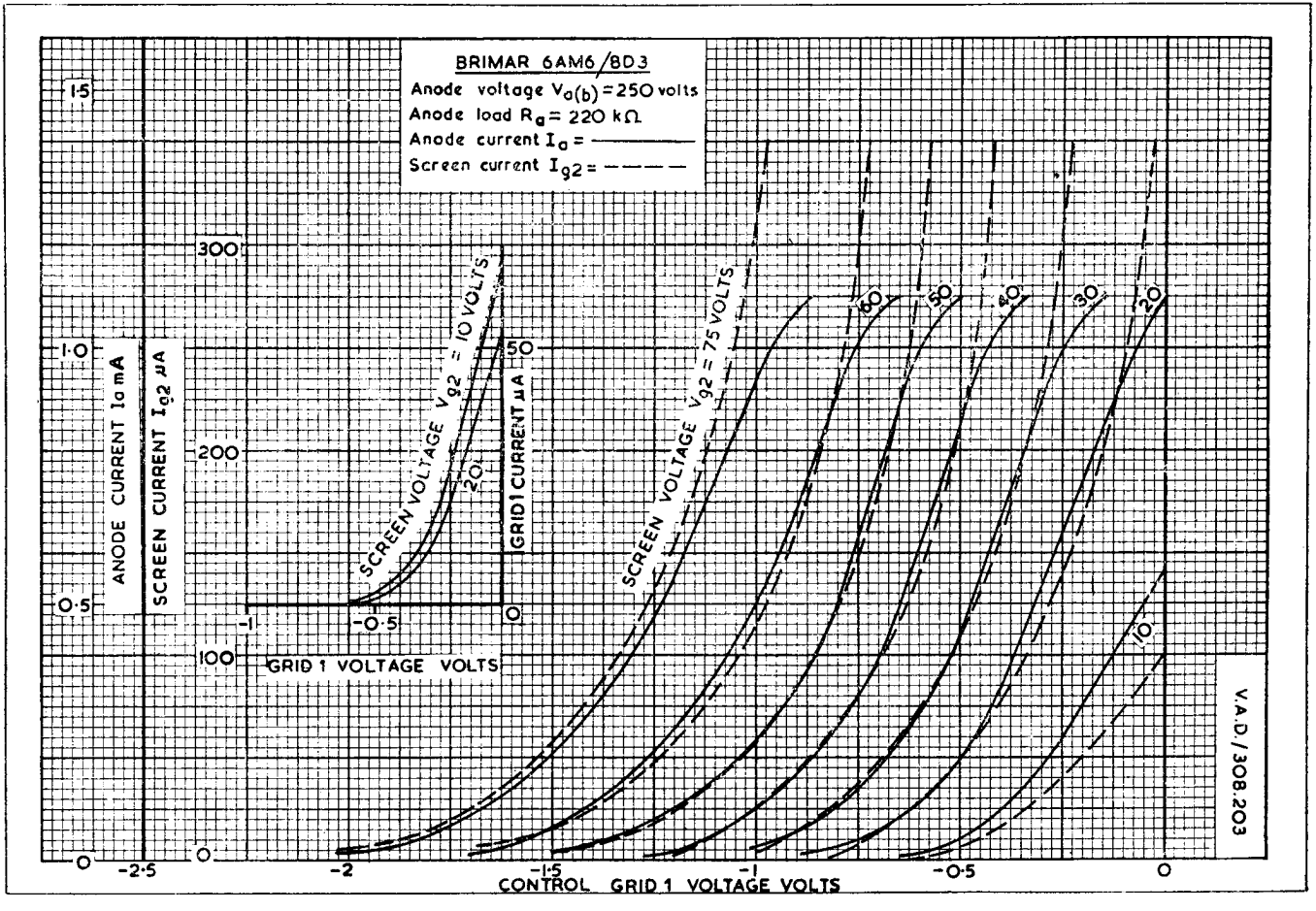

BRIMAR 6AM6/8D3
INPUT RESISTANCE versus GRID 3 VOLTAGE
at 90 Mc/s
Anode supply voltage $V_{a(b)}$ = 250 volts
Screen supply voltage $V_{g2(b)}$ = 250 volts
Grid 1 voltage V_{g1} = 6% of grid 3 voltage V_{g3}
Cathode bias resistor R_k = 160 ohms
INPUT RESISTANCE r_{in} kΩ
INPUT CAPACITY c_{in} pF
MUTUAL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

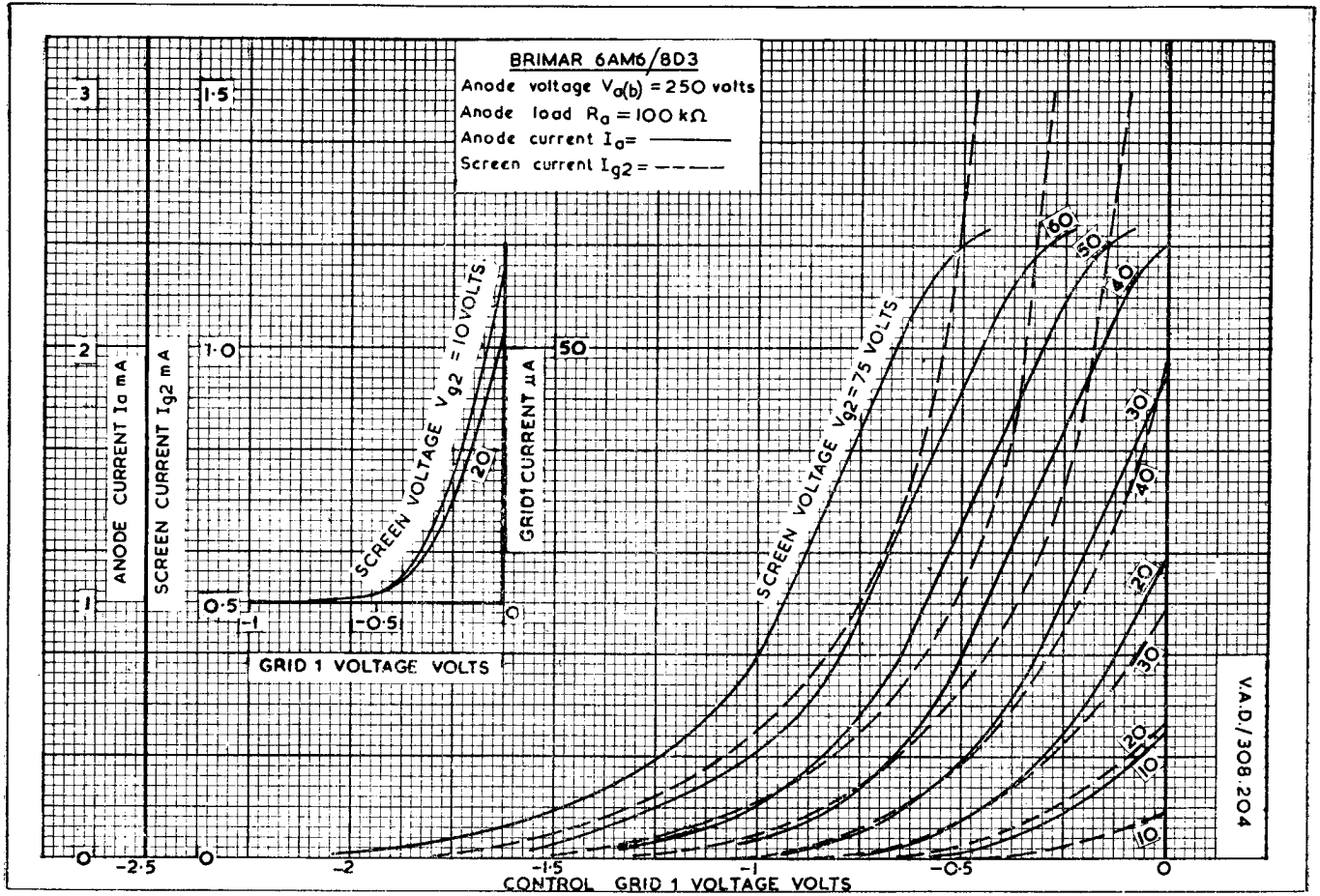

BRIMAR 6AM6/8D3
Anode voltage Va = 250 volts
Screen voltage Vg2 = 250 volts
V.A.D./308 48
ra
gm
MUTUAL CONDUCTANCE gm mA/V
ANODE IMPEDANCE ra MΩ
CONTROL GRID 1 VOLTAGE VOLTS
10
5
0
-7
-6
-5
-4
-3
-2
-1
0

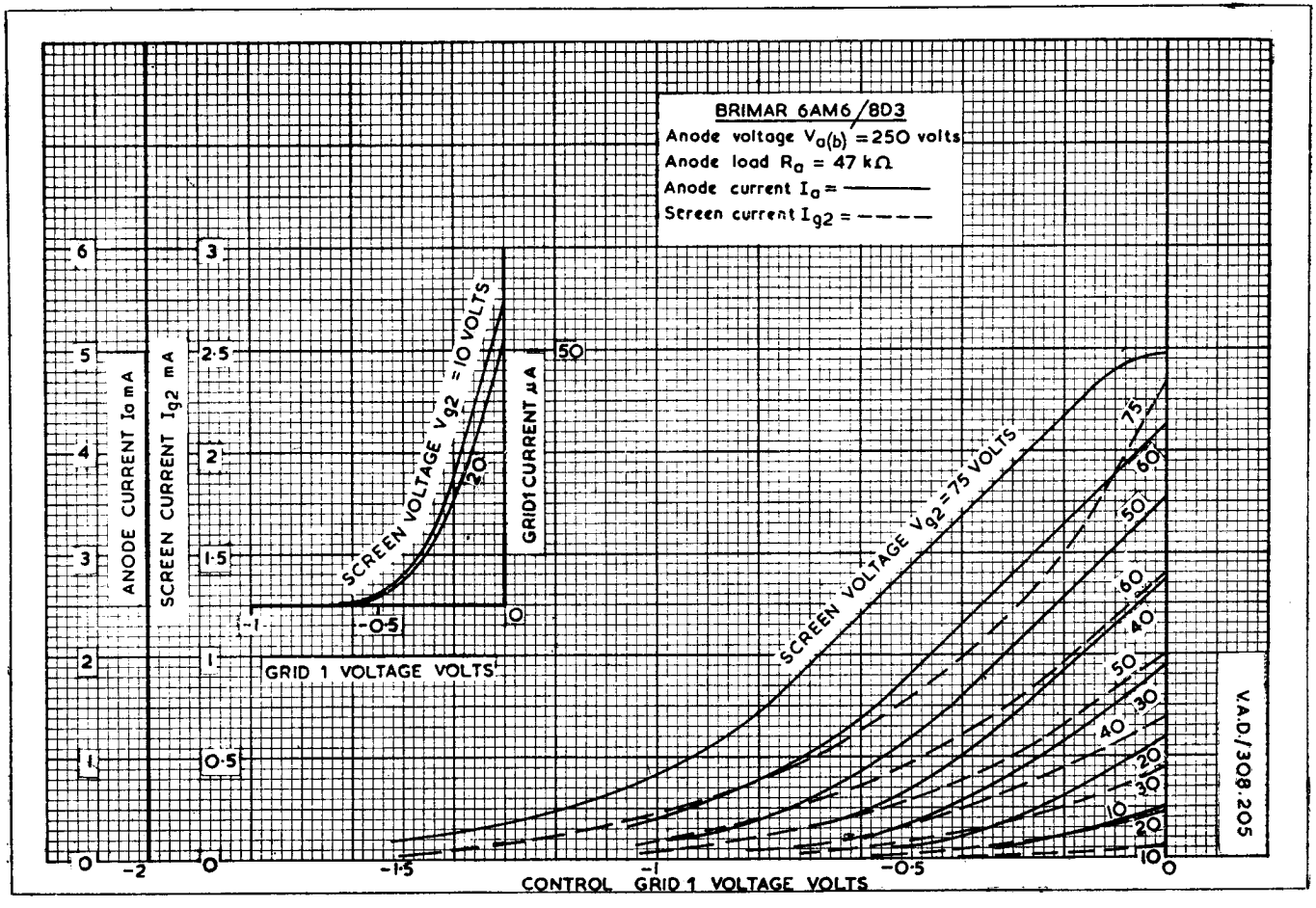

BRIMAR 6AM6/8D3
ANODE CURRENT versus ANODE VOLTAGE
Screen voltage V_{g2} = 250 volts
GRID 1 VOLTAGE Vg1 = 0
-1
-2
-3
-4
-5
30
20
10
0
ANODE CURRENT mA
0
100
200
300
400
ANODE VOLTAGE VOLTS
V.A.D./308.49

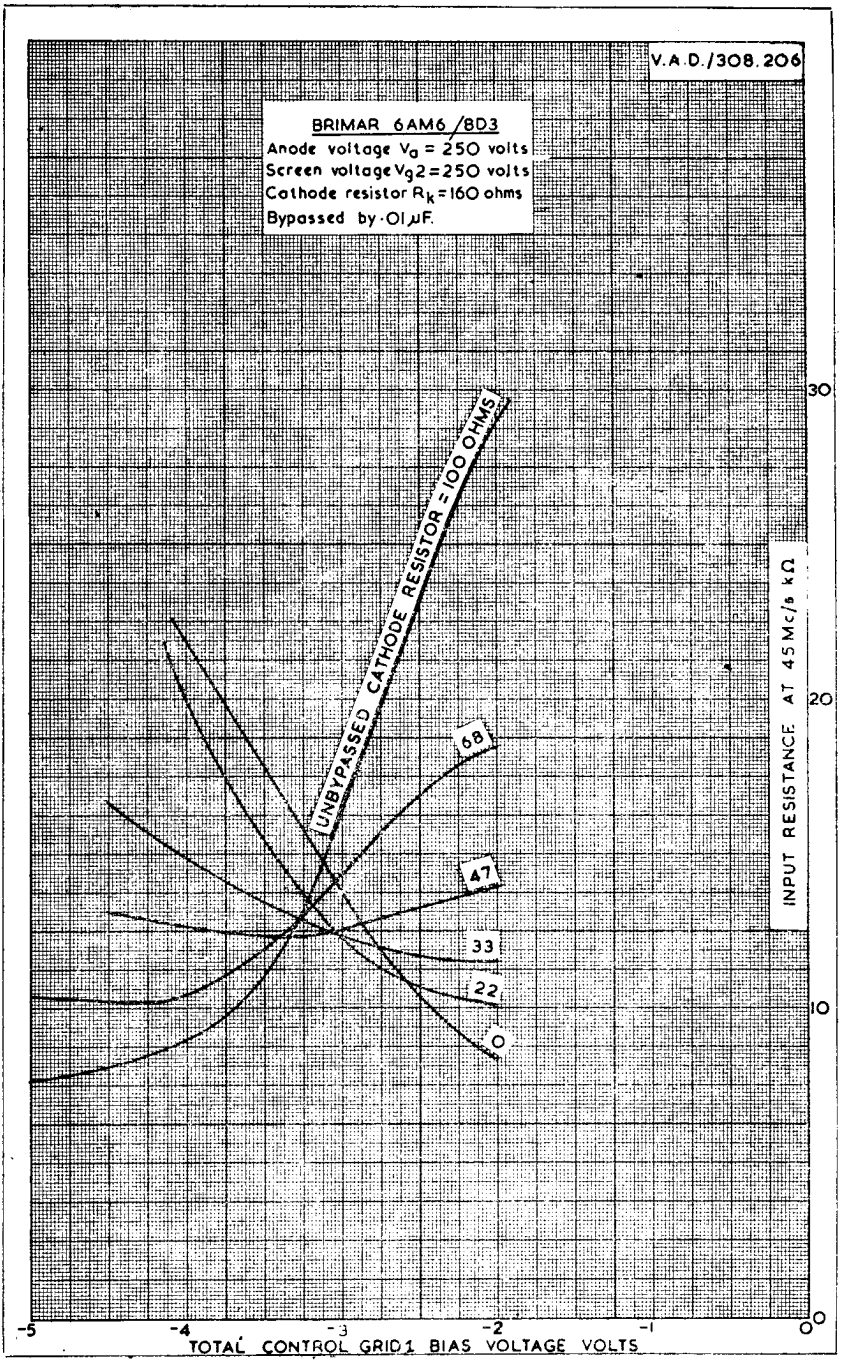

BRIMAR 6AM6/8D3
ANODE CURRENT versus ANODE VOLTAGE
Screen voltage V_{g2} = 200 volts
GRID 1 VOLTAGE Vg1 =0
-1
-2
-3
-4
ANODE CURRENT mA
30
20
10
0
0
100
200
300
400
ANODE VOLTAGE VOLTS
V.A.D./308.201

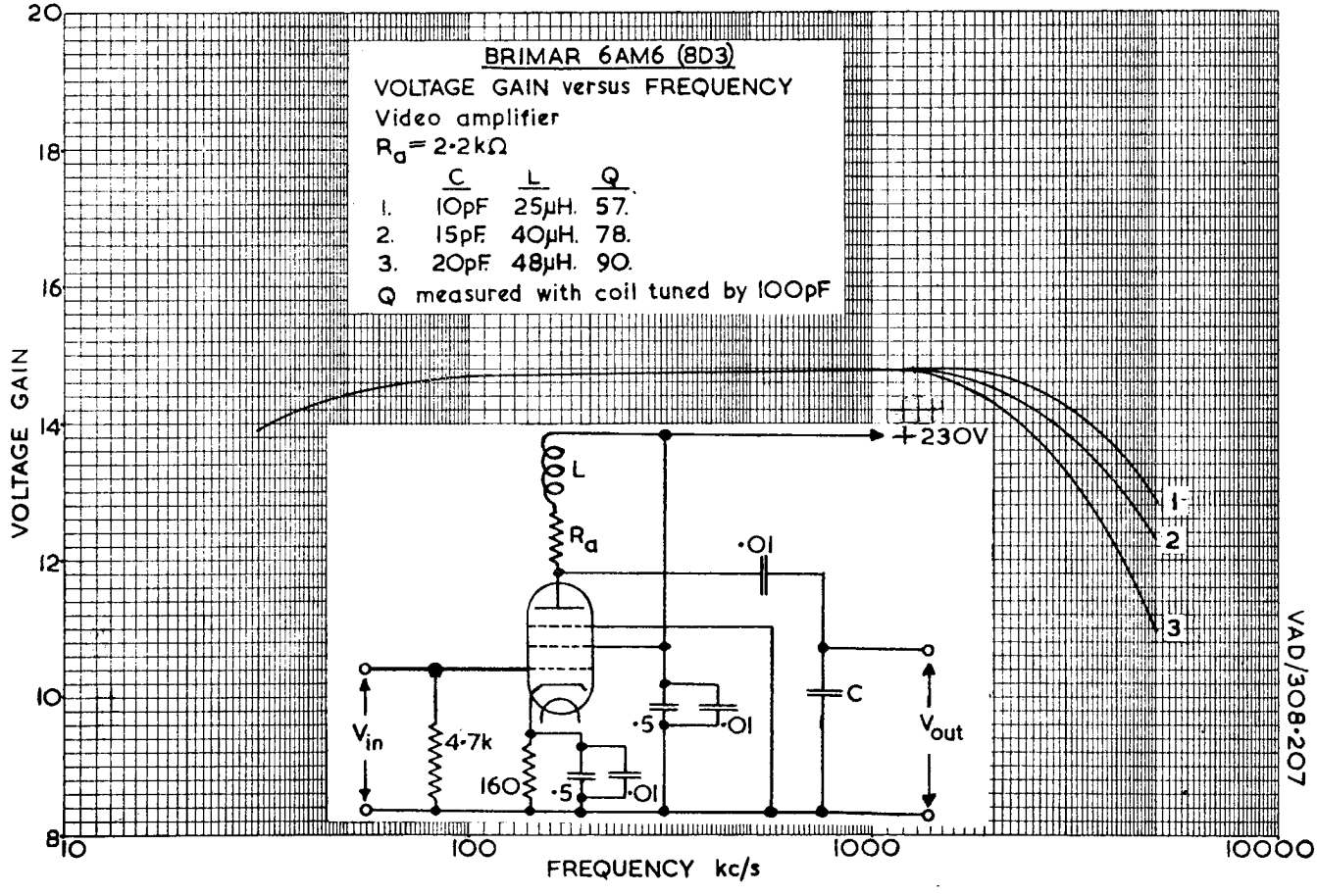

BRIMAR 6AM6/8D3
Anode voltage $V_{a(b)}$ = 250 volts
Anode load R_a = 470 kΩ
Anode current I_a = ———
Screen current I_{g2} = – – – –
ANODE CURRENT I_a μA
SCREEN CURRENT I_{g2} μA
GRID I CURRENT μA
SCREEN VOLTAGE V_{g2} = 10 VOLTS
SCREEN VOLTAGE V_{g2} = 75 VOLTS
600
400
200
0
300
200
100
0
50
20
0
-1
-0·5
60
50
40
30
20
10
10
-2·5
-2
-1·5
-1
-0·5
0
CONTROL GRID 1 VOLTAGE VOLTS
V.A.D./308.202

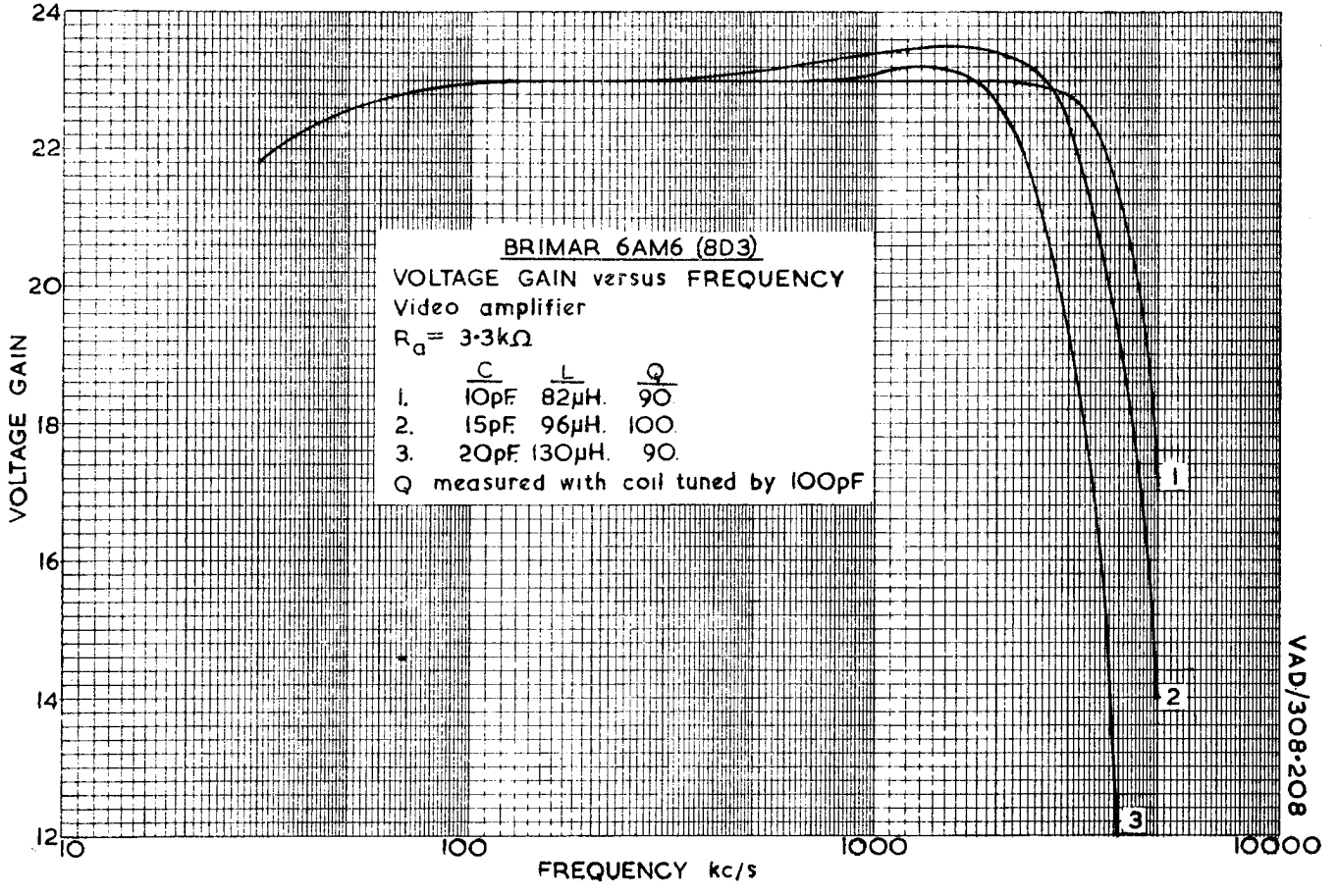

BRIMAR 6AM6/8D3
Anode voltage $V_{a(b)}$ = 250 volts
Anode load R_a = 220 kΩ
Anode current I_a = ———
Screen current I_{g2} = — — —
ANODE CURRENT Ia mA
SCREEN CURRENT I_{g2} μA
GRID 1 CURRENT μA
SCREEN VOLTAGE V_{g2} = 10 VOLTS
SCREEN VOLTAGE V_{g2} = 75 VOLTS
60
50
40
30
20
10
GRID 1 VOLTAGE VOLTS
CONTROL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

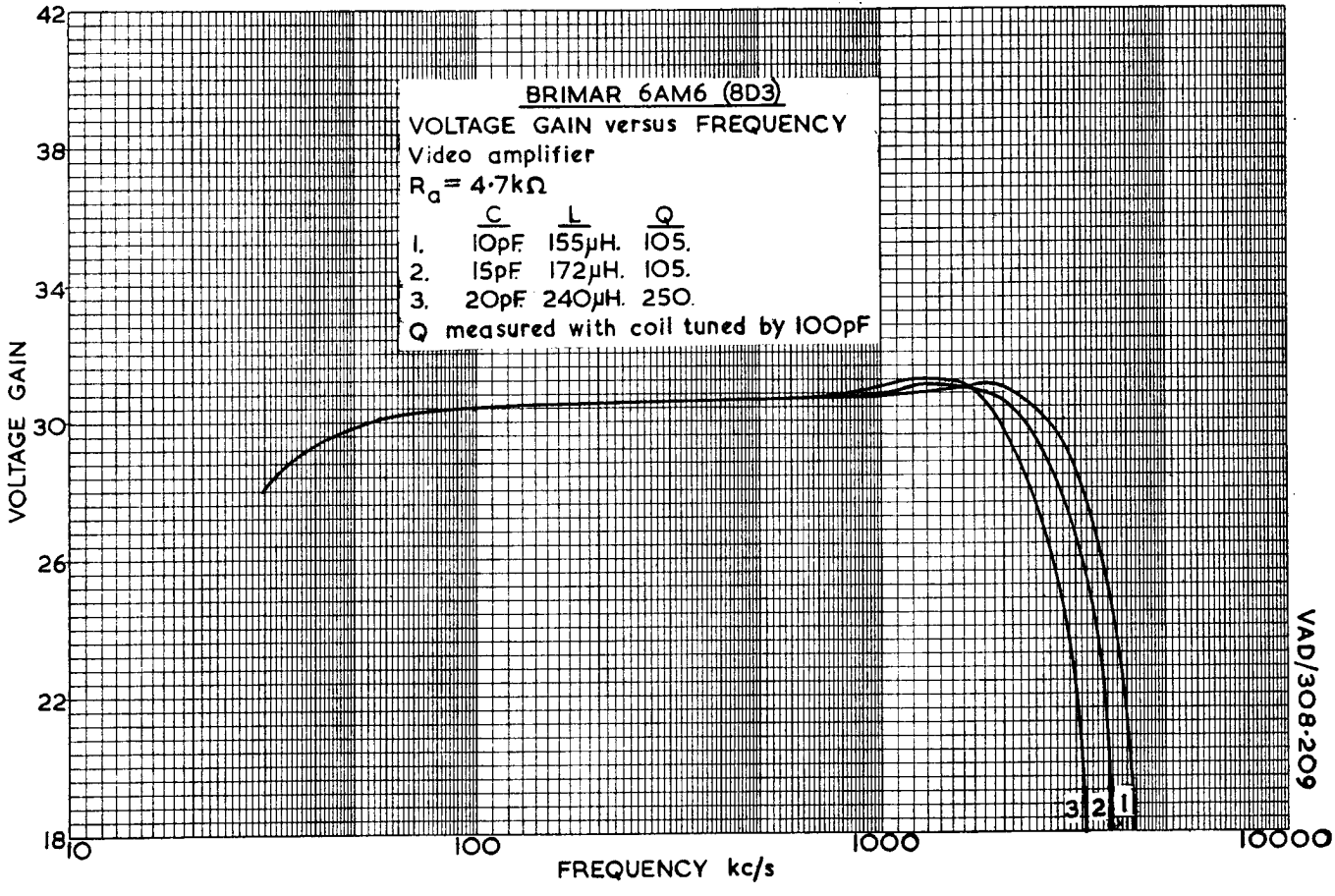

BRIMAR 6AM6/8D3
Anode voltage Va(b) = 250 volts
Anode load Ra = 100 kΩ
Anode current Ia= ———
Screen current Ig2 = – – – –
ANODE CURRENT Ia mA
SCREEN CURRENT Ig2 mA
SCREEN VOLTAGE Vg2 = 10 VOLTS
GRID1 CURRENT µA
GRID 1 VOLTAGE VOLTS
SCREEN VOLTAGE Vg2 = 75 VOLTS
CONTROL GRID 1 VOLTAGE VOLTS
V.A.D./308.204

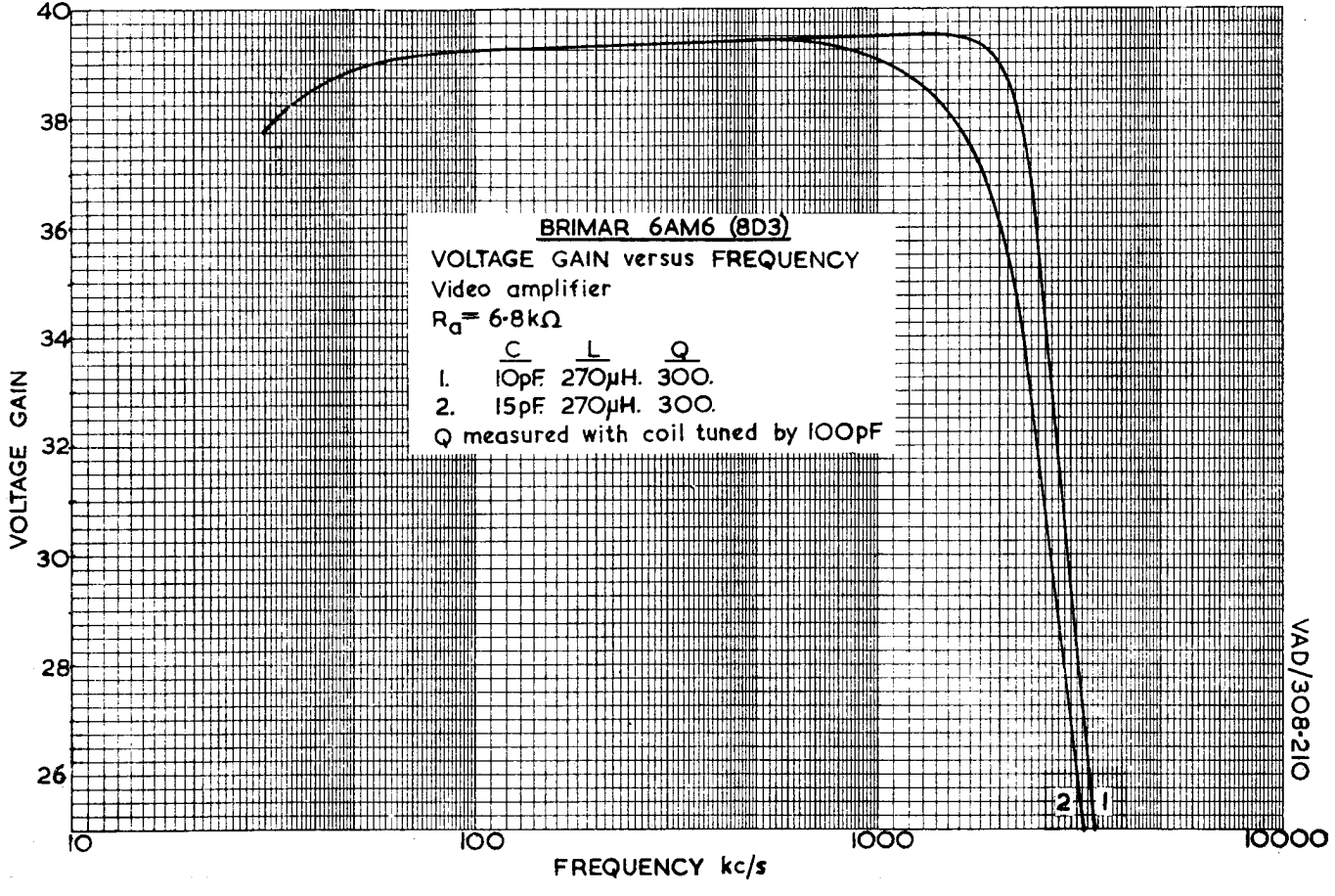

BRIMAR 6AM6/8D3
Anode voltage $V_{a(b)}$ = 250 volts
Anode load R_a = 47 kΩ
Anode current I_a = ———
Screen current I_{g2} = – – – –
ANODE CURRENT Ia mA
SCREEN CURRENT Ig2 mA
GRID CURRENT µA
SCREEN VOLTAGE Vg2 = 10 VOLTS
GRID 1 VOLTAGE VOLTS
SCREEN VOLTAGE Vg2 = 75 VOLTS
CONTROL GRID 1 VOLTAGE VOLTS
VA.D/308.205

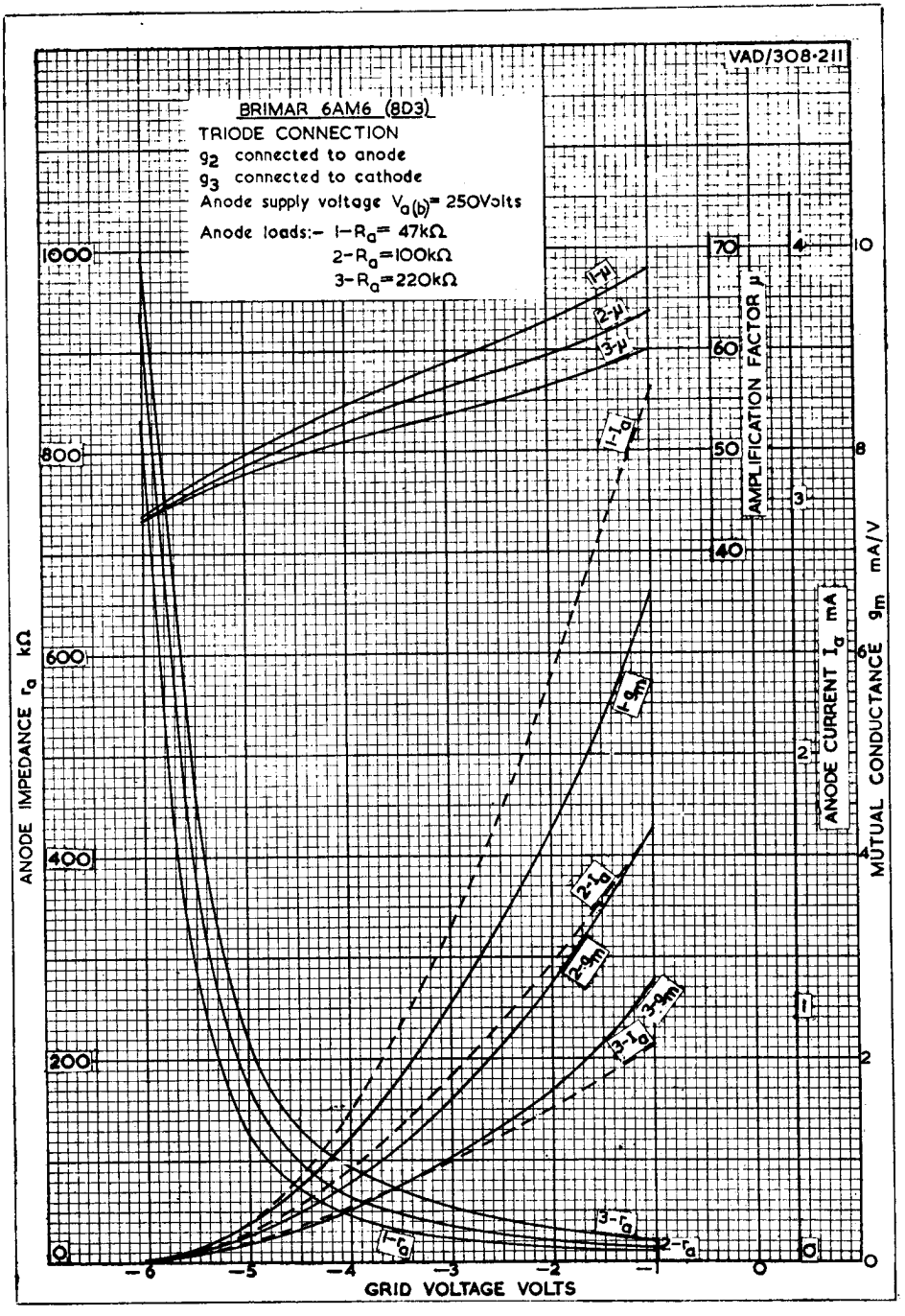

V.A.D./308.206
BRIMAR 6AM6 / 8D3
Anode voltage V_a = 250 volts
Screen voltage V_{g2} = 250 volts
Cathode resistor R_k = 160 ohms
Bypassed by ·01 μF.
UNBYPASSED CATHODE RESISTOR = 100 OHMS
68
47
33
22
0
INPUT RESISTANCE AT 45 Mc/s kΩ
30
20
10
0
-5
-4
-3
-2
-1
0
TOTAL CONTROL GRID 1 BIAS VOLTAGE VOLTS

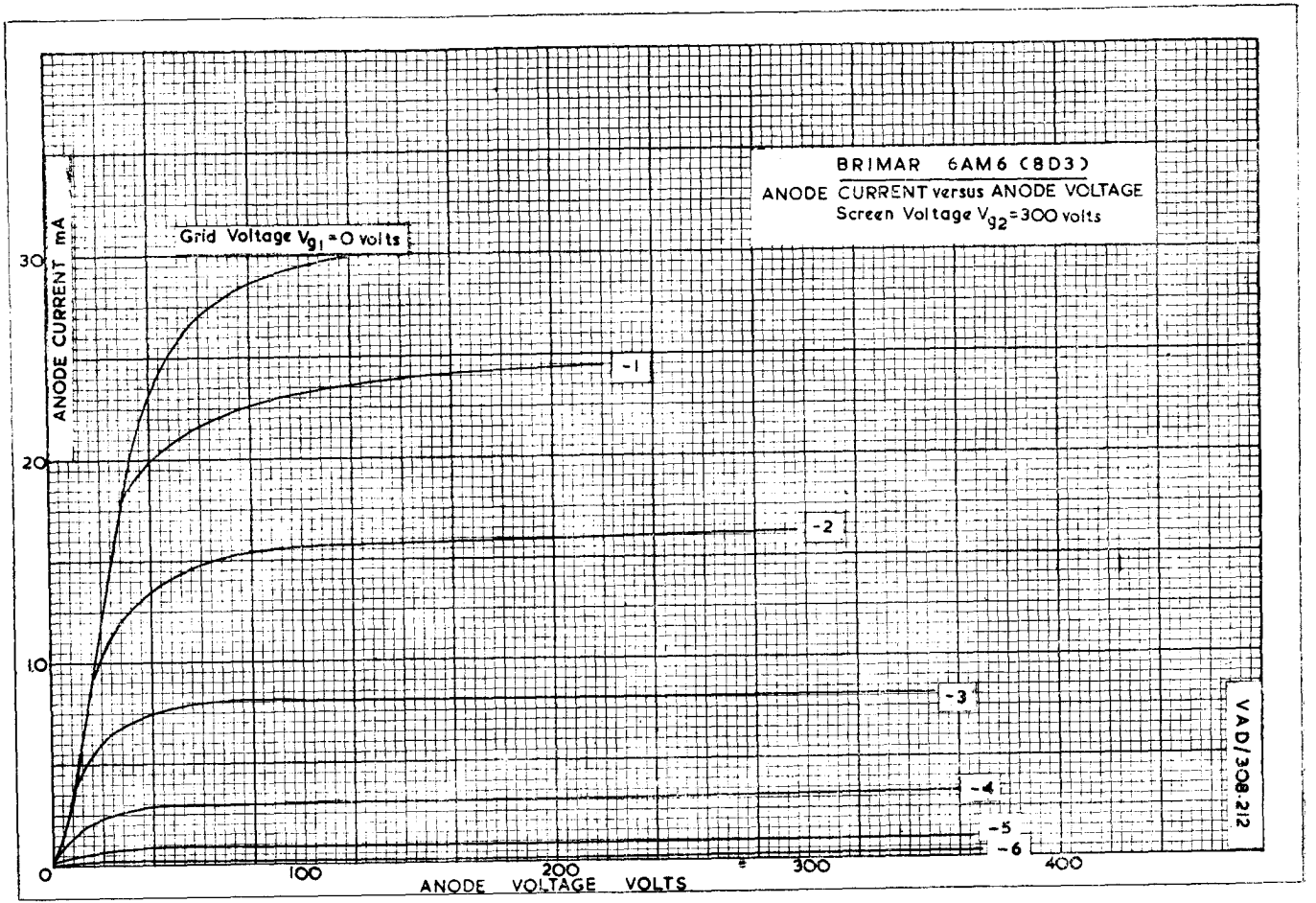

BRIMAR 6AM6 (8D3)
VOLTAGE GAIN versus FREQUENCY
Video amplifier
R_a = 2·2kΩ
C L Q
1. 10pF 25μH. 57.
2. 15pF 40μH. 78.
3. 20pF 48μH. 90.
Q measured with coil tuned by 100pF
VOLTAGE GAIN
FREQUENCY kc/s
20
18
16
14
12
10
8
10
100
1000
10000
1
2
3
+230V
L
R_a
·01
·5
·01
C
V_{in}
4·7k
160
·5
·01
V_{out}
VAD/308·207


BRIMAR 6AM6 (8D3)
VOLTAGE GAIN versus FREQUENCY
Video amplifier
R_a = 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 = 4·7kΩ
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 = 6·8kΩ
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
10
100
1000
10000
FREQUENCY kc/s
2
1
VAD/308-210

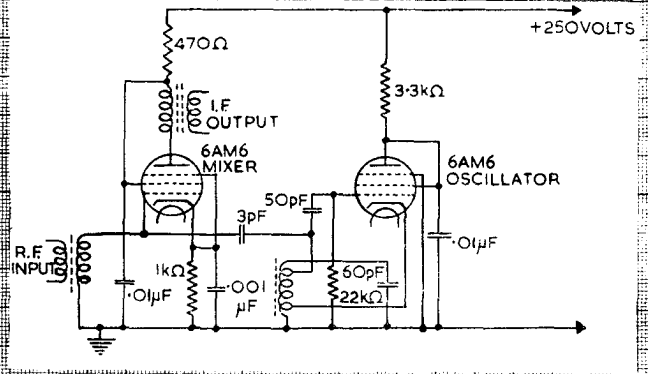

VAD/308·211
BRIMAR 6AM6 (8D3)
TRIODE CONNECTION
g_2 connected to anode
g_3 connected to cathode
Anode supply voltage $V_{a(b)}$= 250Volts
Anode loads:- 1-R_a= 47kΩ
2-R_a=100kΩ
3-R_a=220kΩ
1-μ
2-μ
3-μ
1-I_a
1-g_m
2-I_a
2-g_m
3-g_m
3-I_a
1-r_a
3-r_a
2-r_a
ANODE IMPEDANCE r_a kΩ
AMPLIFICATION FACTOR μ
MUTUAL CONDUCTANCE g_m mA/V
ANODE CURRENT I_a mA
GRID VOLTAGE VOLTS
1000
800
600
400
200
0
70
60
50
40
10
8
6
4
2
0
−6
−5
−4
−3
−2
−1
0

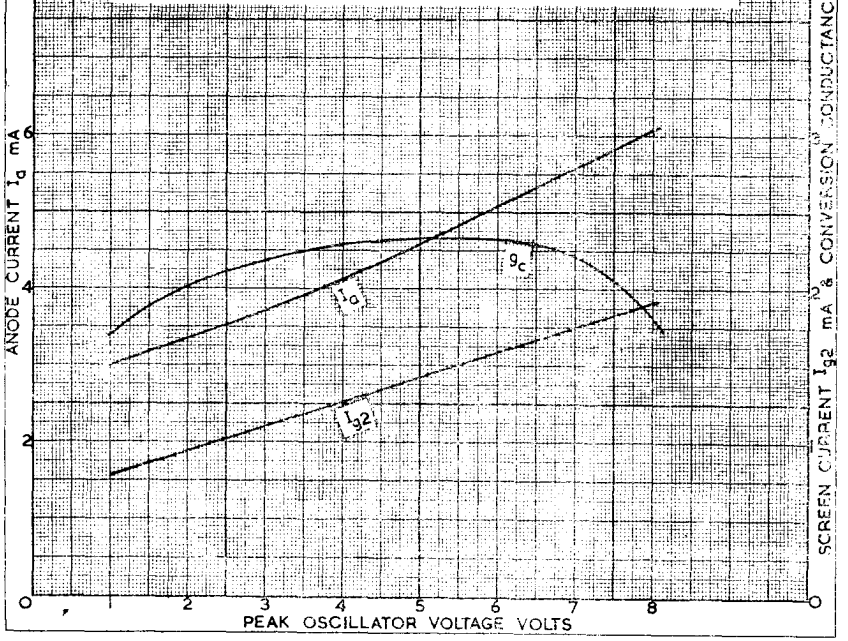

BRIMAR 6AM6 (8D3)
ANODE CURRENT versus ANODE VOLTAGE
Screen Voltage V_{g2} = 300 volts
Grid Voltage V_{g1} = 0 volts
-1
-2
-3
-4
-5
-6
ANODE CURRENT mA
30
20
10
0
100
200
300
400
ANODE VOLTAGE VOLTS
VAD/308.212

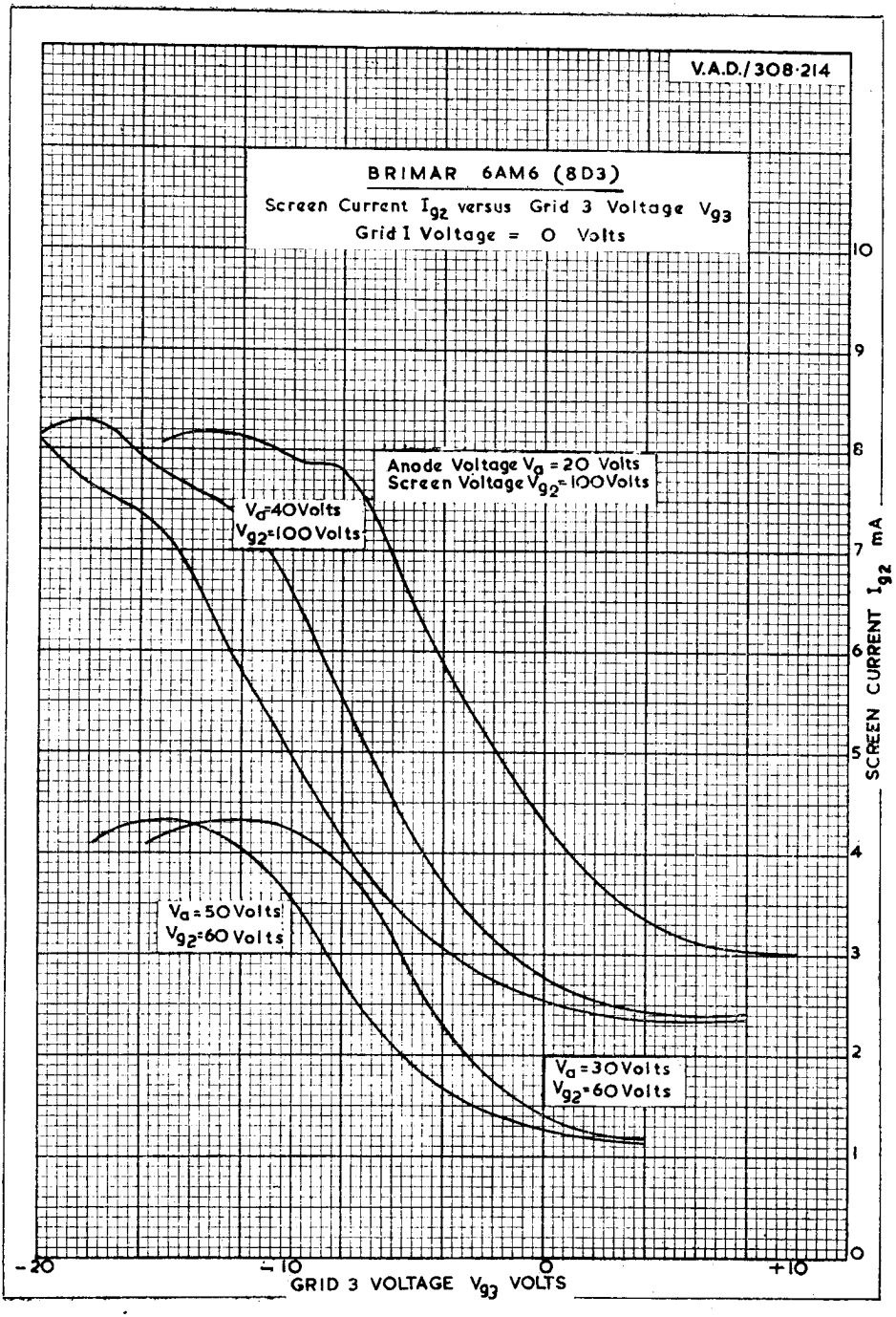
VAD/308-213

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






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

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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:

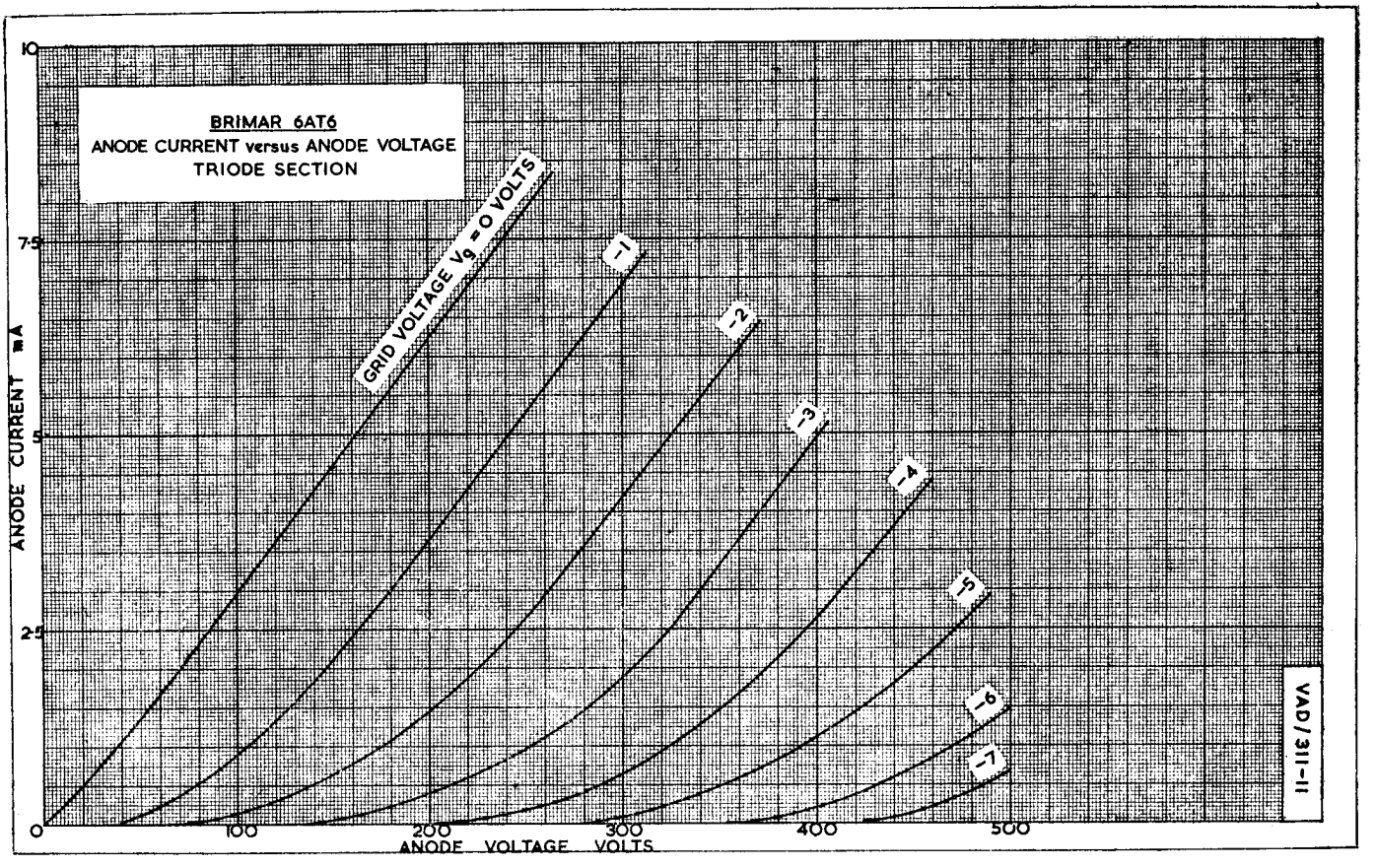
Anode Load (R_a megohms)	0·22	0·22	0·47	0·47
Grid Leak (succeeding valve) (megohms)	0·22	0·47	0·47	1·0
Output Voltage (peak)	42	54	47	60
Voltage Gain	46	51	53	56

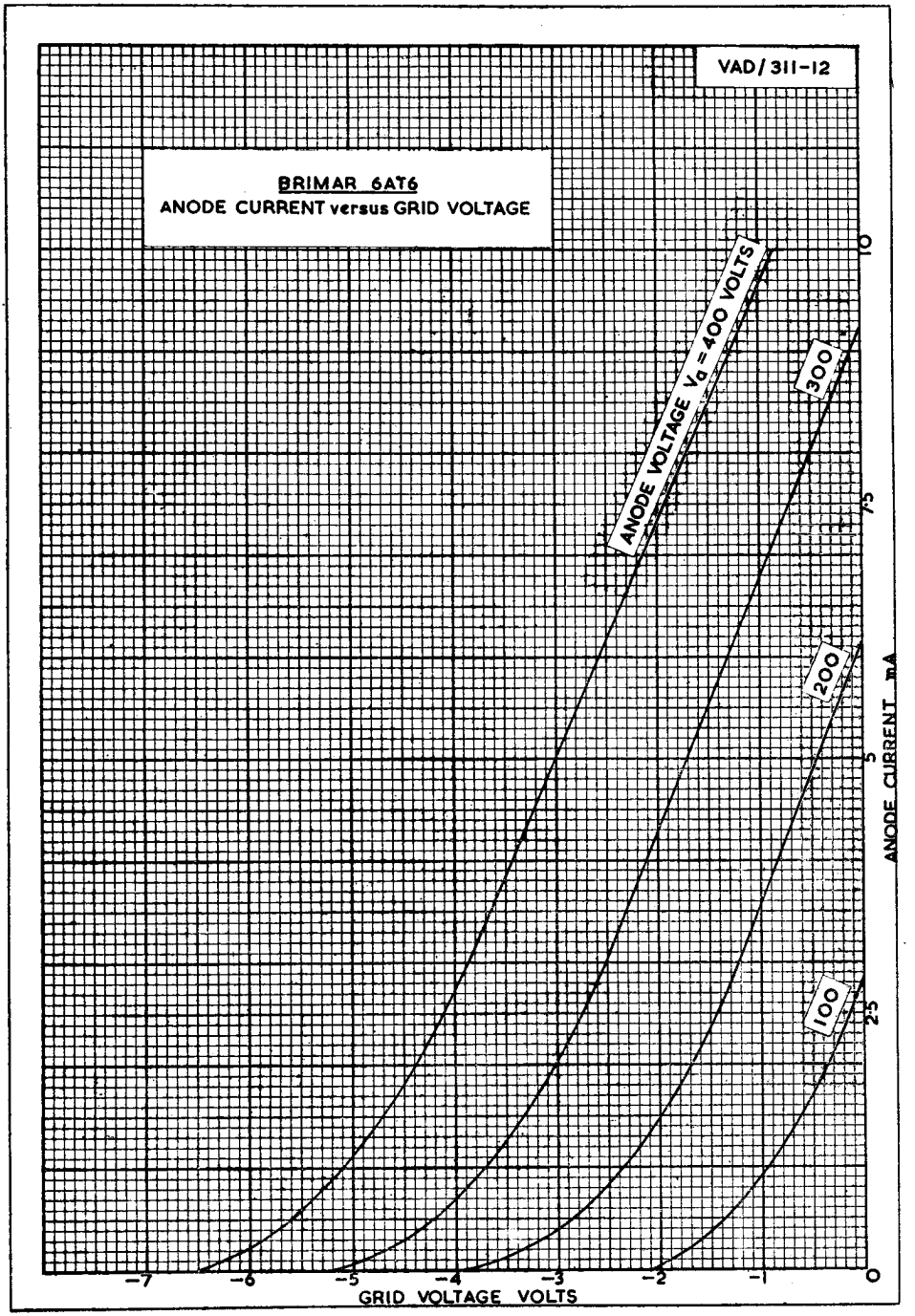
DIODE UNIT:

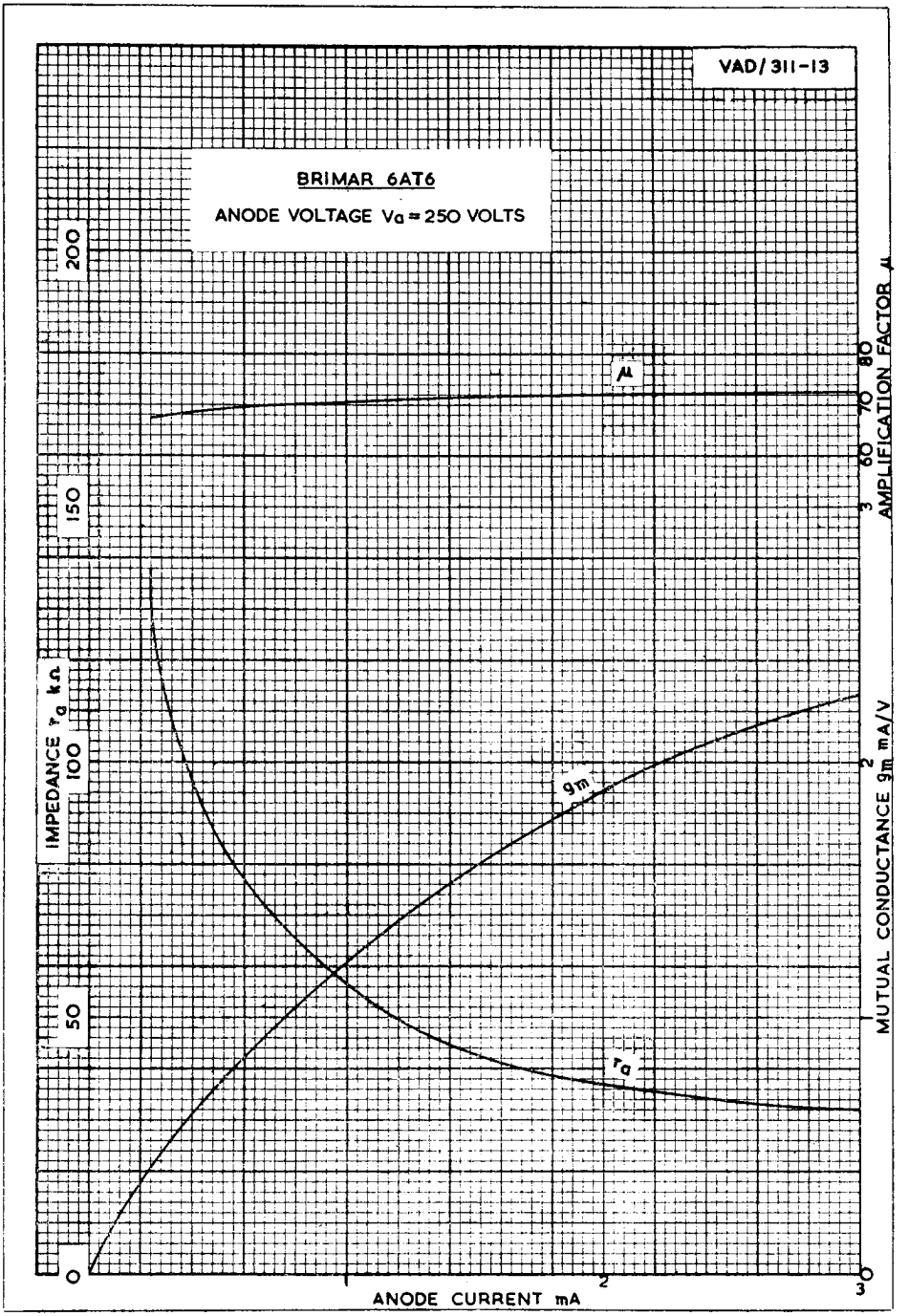
Half-Wave Rectification: A graph is attached which shows the performance of either diode when used as a signal rectifier (Curve No. 311·16). Load lines have been drawn for DC loads of 0·1, 0·22, 0·47 and 1·0 megohm. It should be remembered that in order to determine the performance, further load lines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

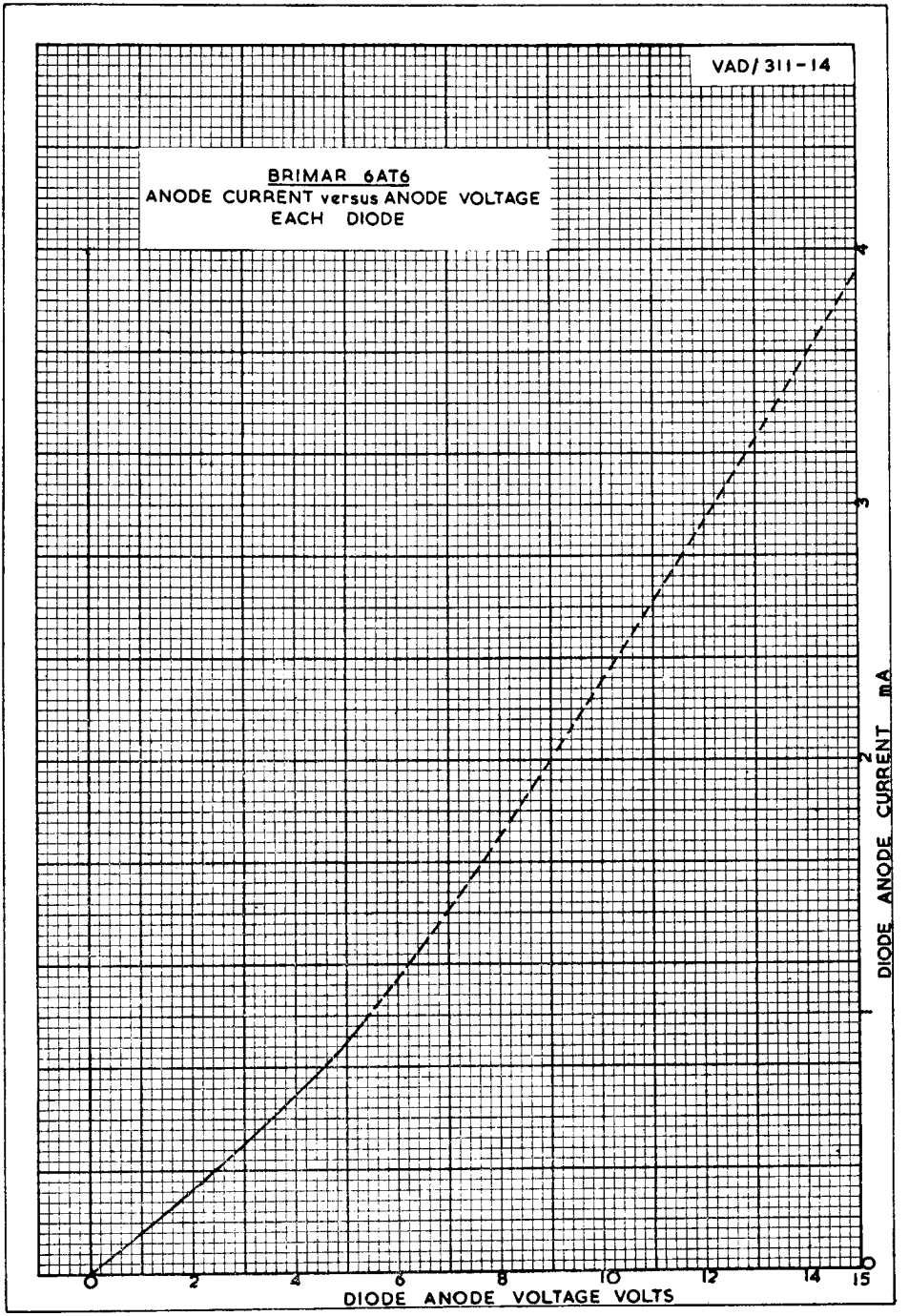
Full-Wave Rectification: The diodes may be employed as signal rectifiers in a full-wave circuit if required.

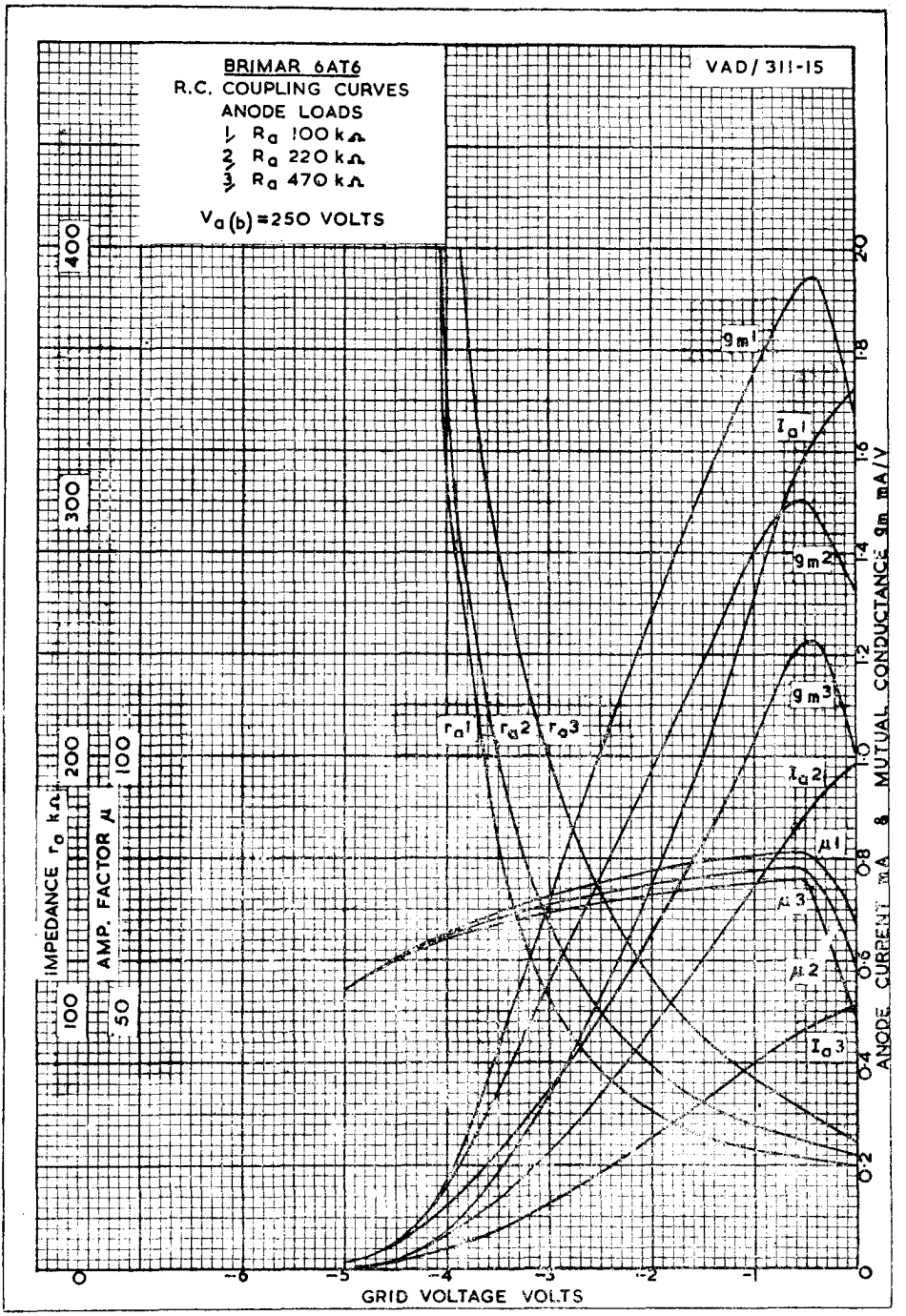
Combined Detector and AF Amplifier: The circuit (Ref. 311·55) attached shows a typical arrangement suitable for a receiver of good average performance. The IF pentode may be a type such as a Brimar 6BA6 and a following output valve may be a Brimar 6AQ5, 6BW6 or 6L6G. Using the values shown the distortion 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.

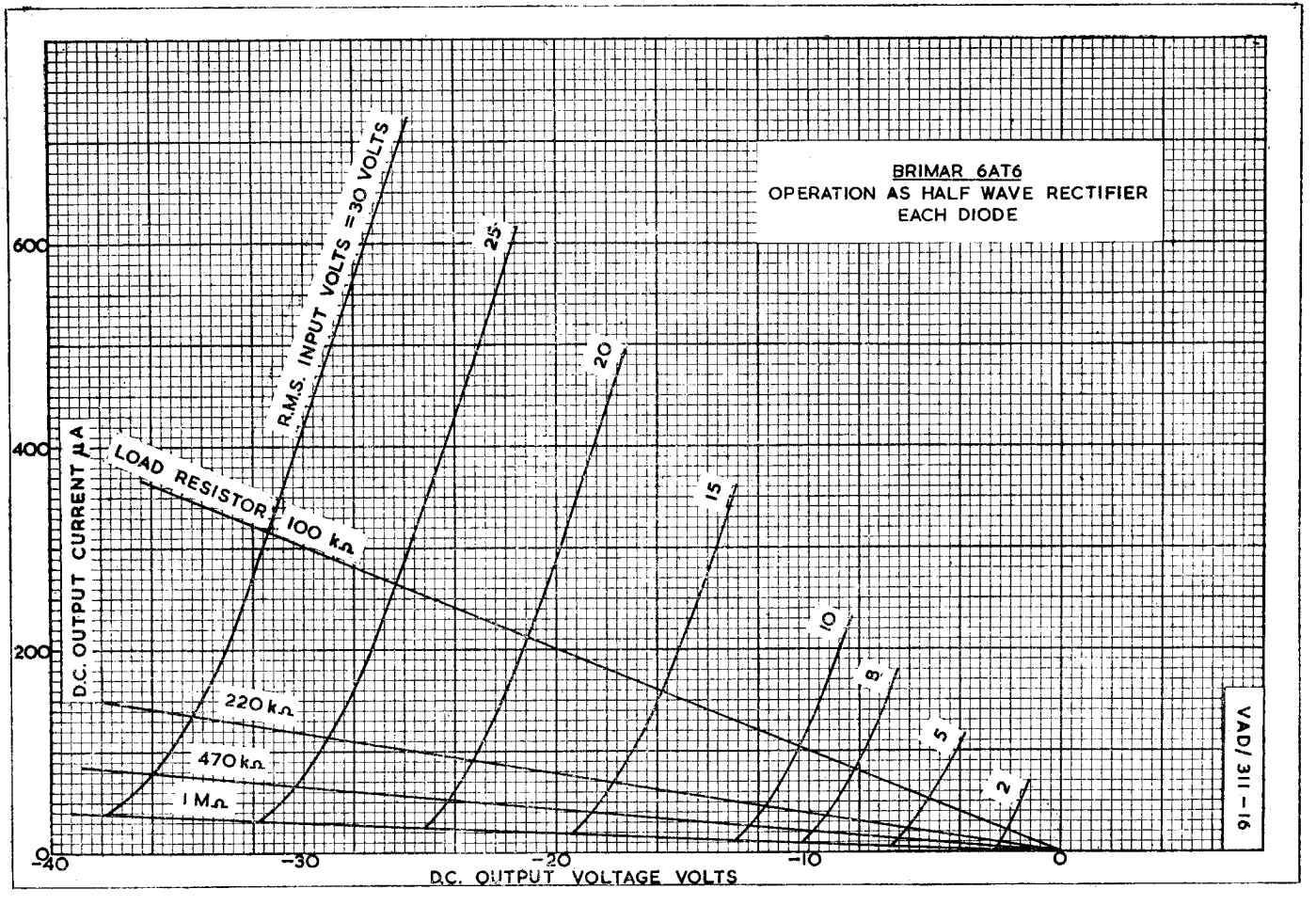

BRIMAR 6AT6
ANODE CURRENT versus ANODE VOLTAGE
TRIODE SECTION
GRID VOLTAGE Vg = 0 VOLTS
-1
-2
-3
-4
-5
-6
-7
ANODE CURRENT mA
10
7·5
5
2·5
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VAD/311-11


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
GRID VOLTAGE VOLTS

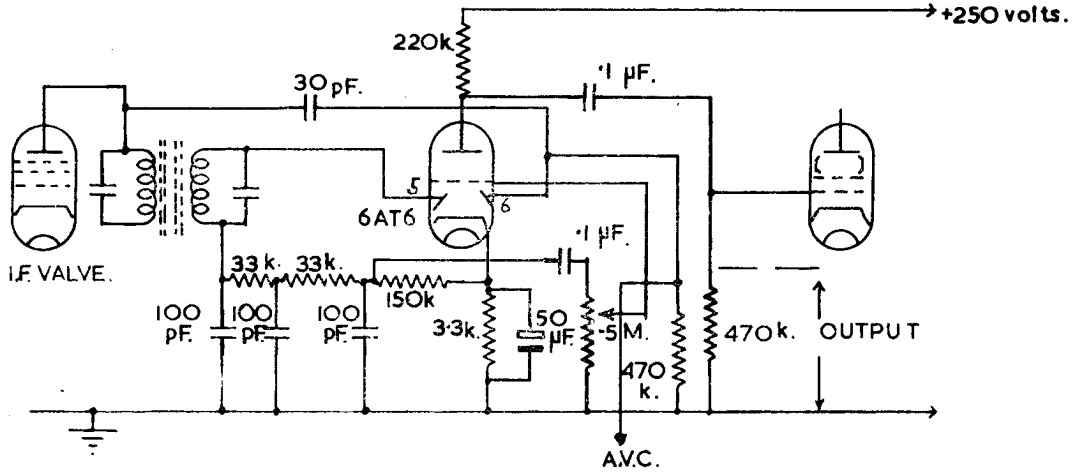

VAD/311-13
BRIMAR 6AT6
ANODE VOLTAGE Va = 250 VOLTS
IMPEDANCE ra kΩ
200
150
100
50
0
μ
gm
ra
AMPLIFICATION FACTOR μ
80
70
60
MUTUAL CONDUCTANCE gm mA/V
3
2
0
ANODE CURRENT mA
1
2
3


VAD/311-14
BRIMAR 6AT6
ANODE CURRENT versus ANODE VOLTAGE
EACH DIODE
DIODE ANODE CURRENT mA
0
1
2
3
4
DIODE ANODE VOLTAGE VOLTS
0
2
4
6
8
10
12
14
15


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
ANODE CURRENT mA & MUTUAL CONDUCTANCE gm mA/V
GRID VOLTAGE VOLTS
gm1
gm2
gm3
Ia1
Ia2
Ia3
ra1
ra2
ra3
μ1
μ2
μ3


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

BRIMAR 6AT6 COMBINED DETECTOR & A.F. AMPLIFIER



FREQUENCY 465 kc/s.

VAD/311.55

BRIMAR

RECEIVING VALVE

6AU6

APPLICATION REPORT VAD/508.1

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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_{in}	5·5 pF
c_{out}	5·0 pF
$c_{g1, a}$	0·0035 pF max.

TRIODE CONNECTED:

c_{in}	3·1 pF
c_{out}	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$0·3 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:

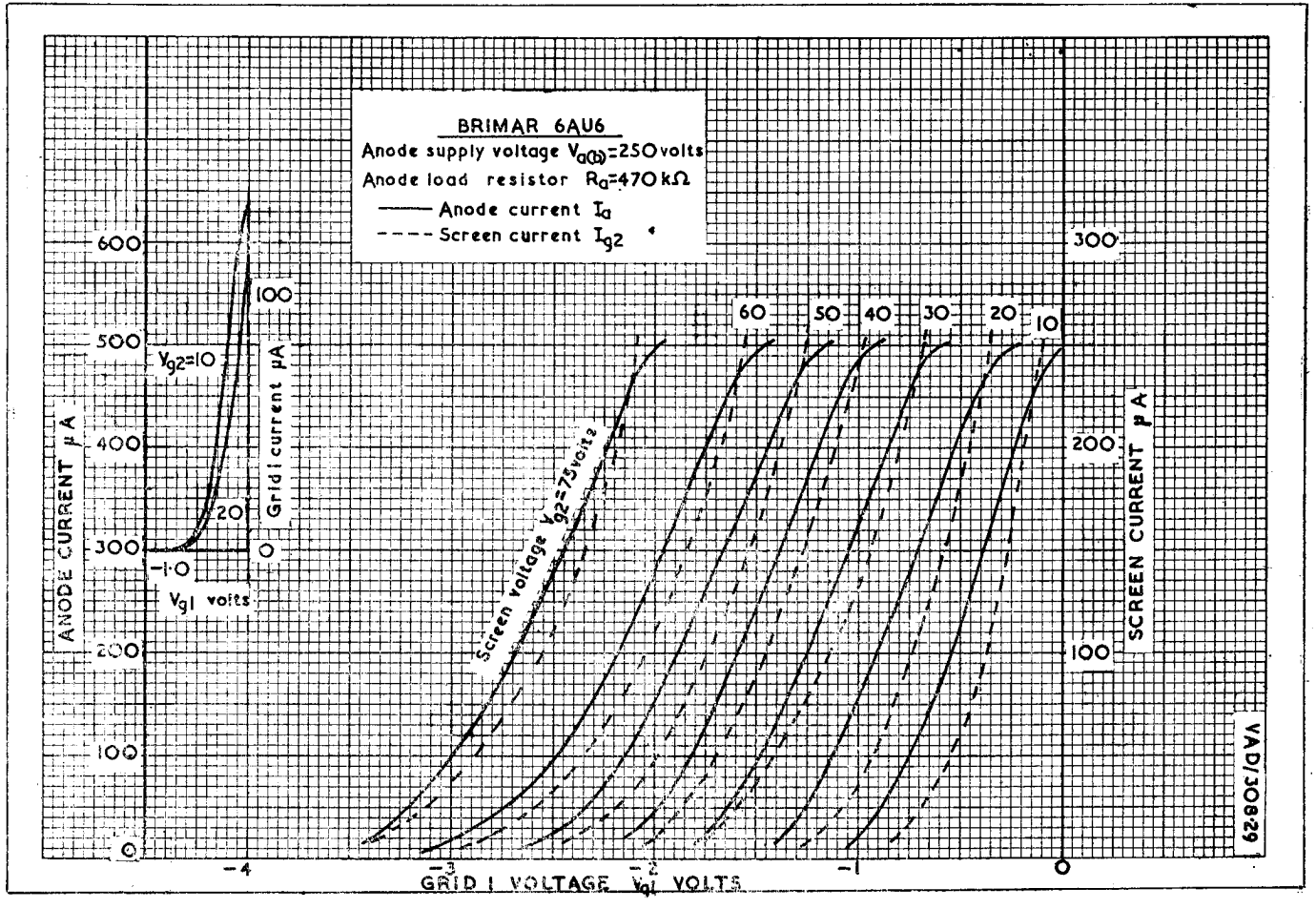
$$\frac{29 \times 150{,}000}{150{,}000 + 26{,}000} = 25$$

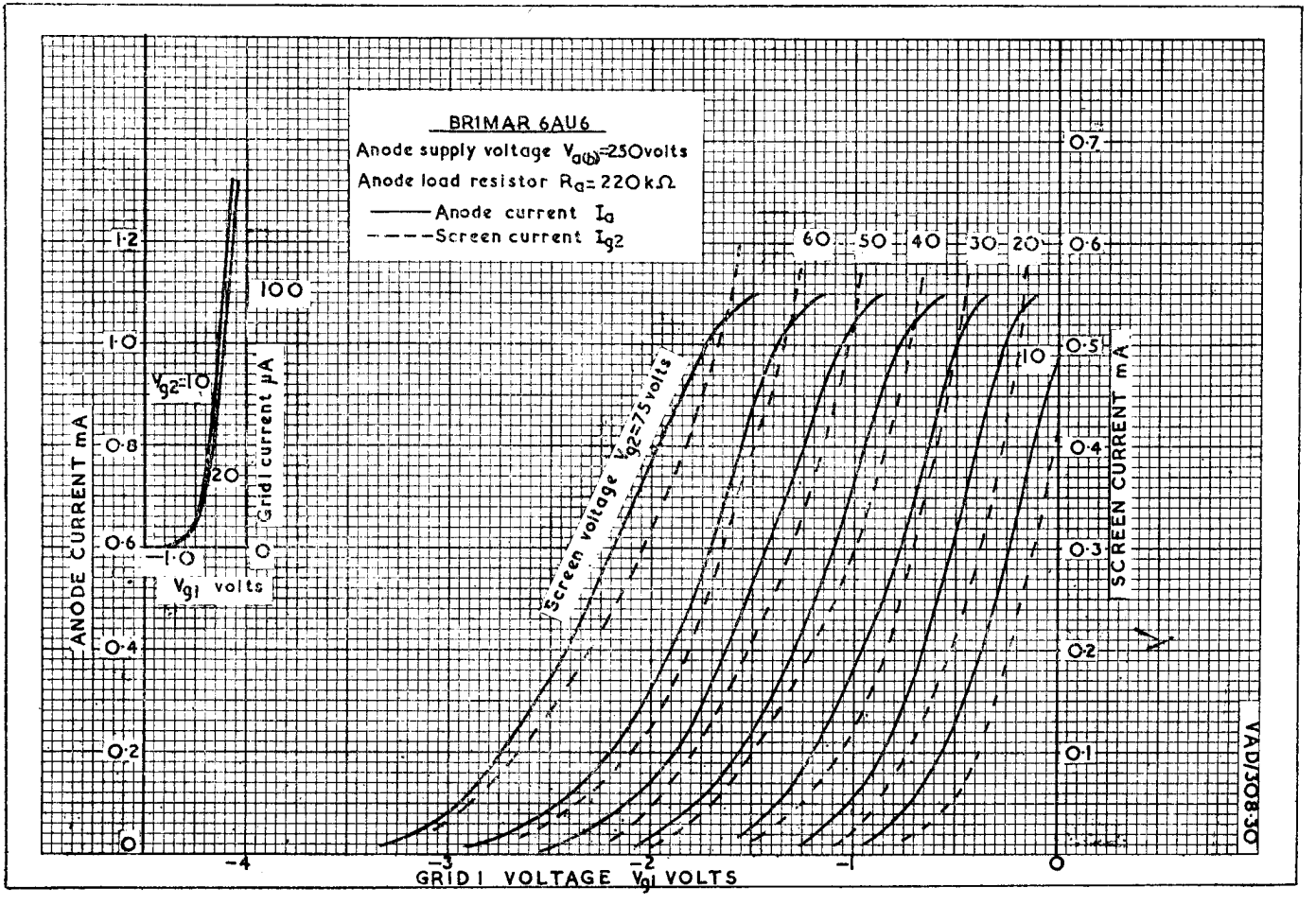
The peak input voltage above was 2·5 volts hence the peak output voltage will be this figure multiplied by the stage gain or 62 volts or 44 volts R.M.S.

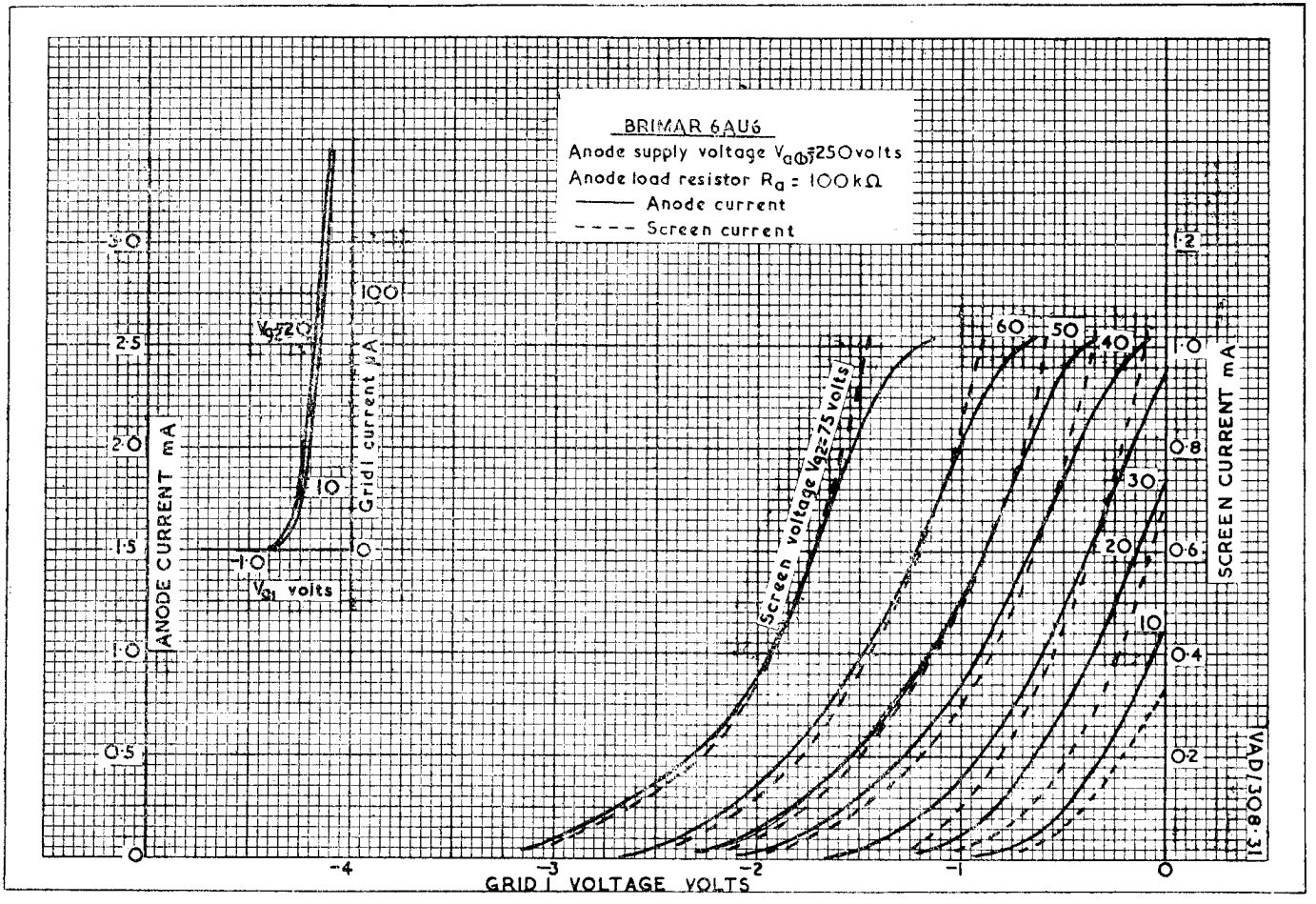
An estimate of the distortion may be made by calculating from the graph as above the stage gain at the extremes of grid bias; in the example the stage gain at —1 volts is 30 and at —6 volts is 20, hence the positive peaks of the signal output will be less than the negative.

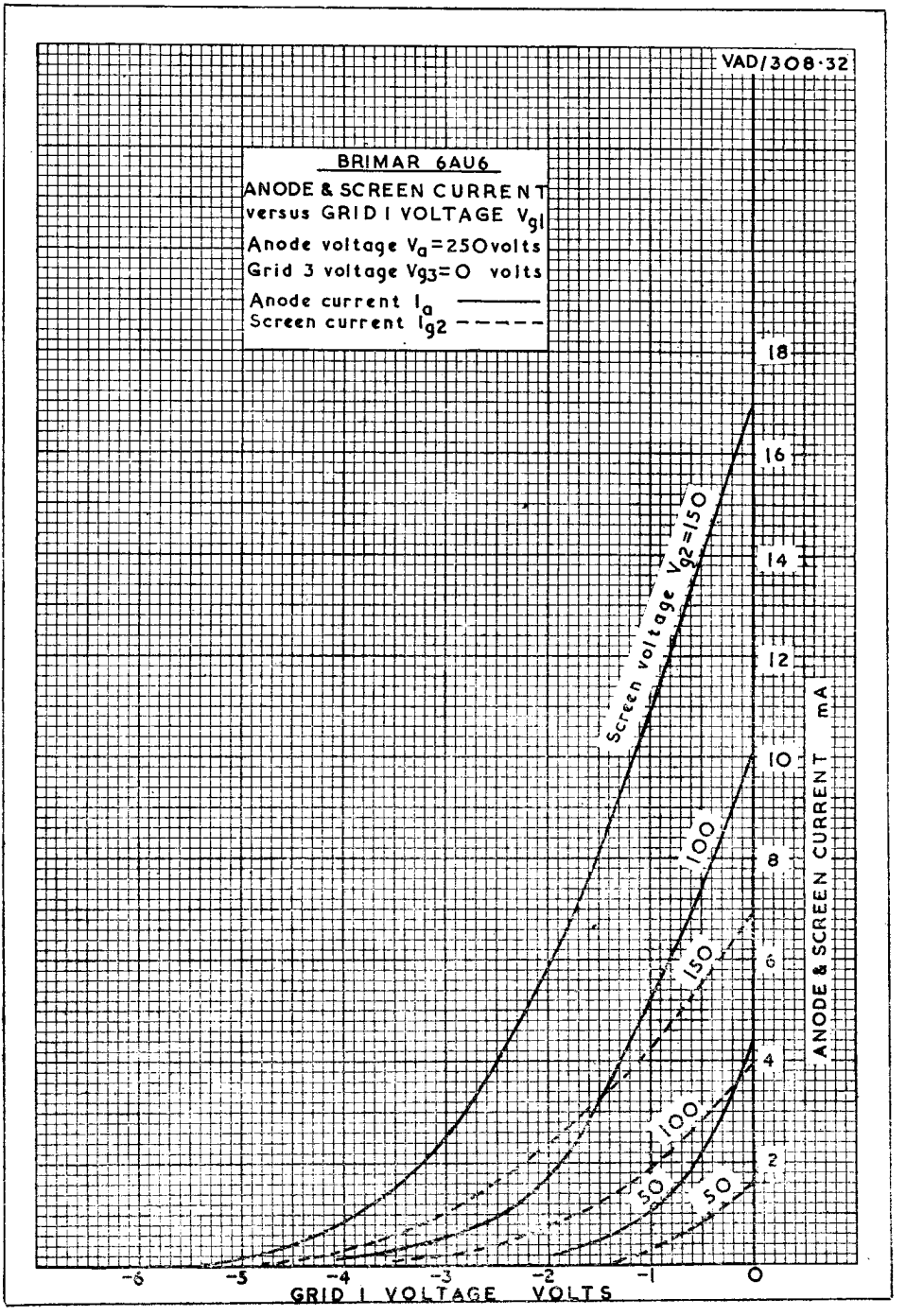
OPERATION AS AN FM LIMITER:

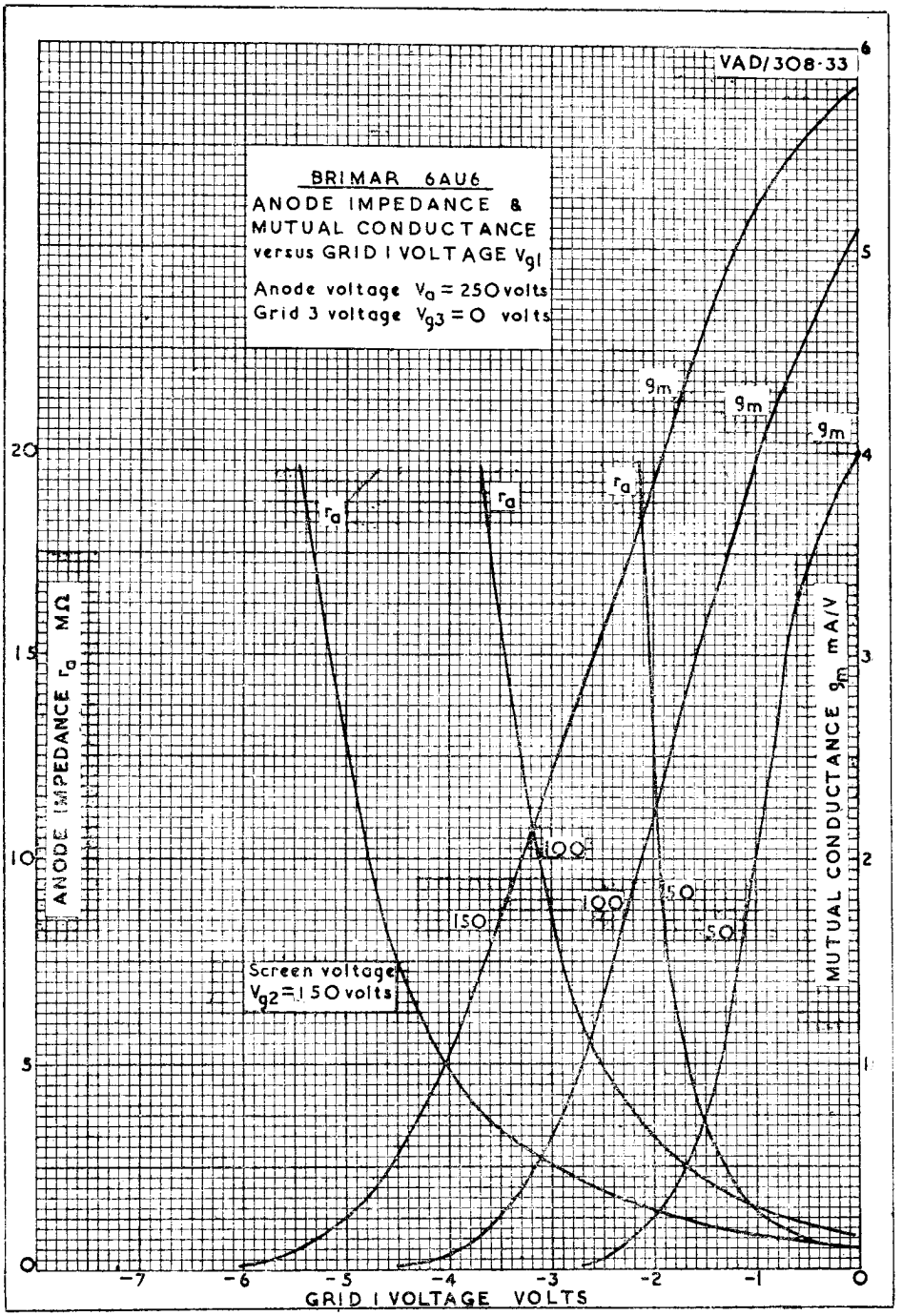
The high slope and short grid base make the valve very suitable for use as a limiter for FM receivers. A curve (No. 308·46) attached to this report, shows the operation as a limiter for two different conditions, Curve No. 1 threshold at 1 volt, and Curve No. 2 for 0·5 volts, the output being approximately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

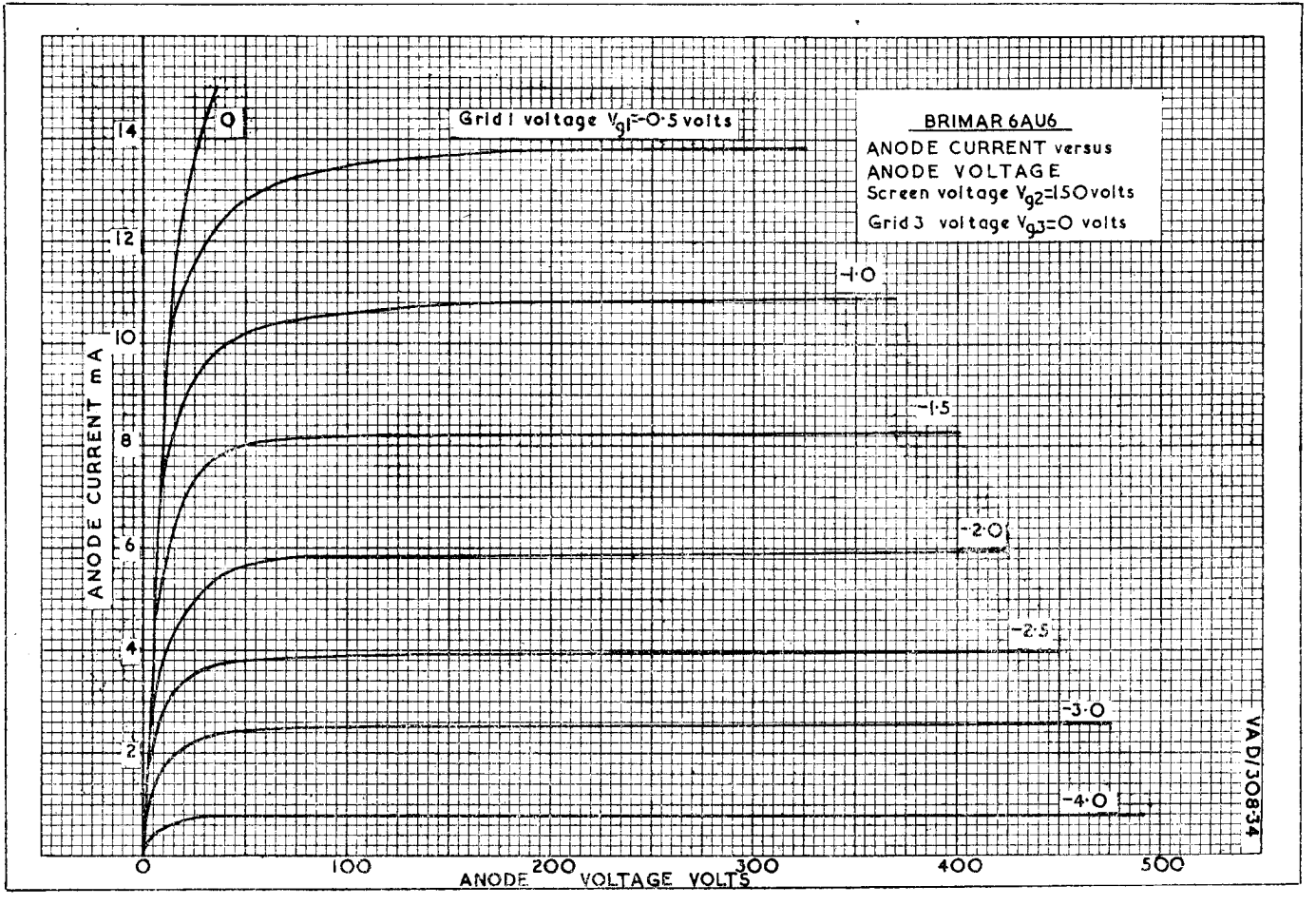

BRIMAR 6AU6
Anode supply voltage $V_{a(b)}$=250 volts
Anode load resistor R_a=470 kΩ
Anode current I_a
Screen current I_{g2}
ANODE CURRENT μA
SCREEN CURRENT μA
Grid current μA
V_{g2}=10
20
0
-1·0
V_{g1} volts
Screen voltage V_{g2}=75 volts
60
50
40
30
20
10
600
500
400
300
200
100
0
300
200
100
-4
-3
-2
-1
0
GRID 1 VOLTAGE V_{g1} VOLTS
VAD/30829

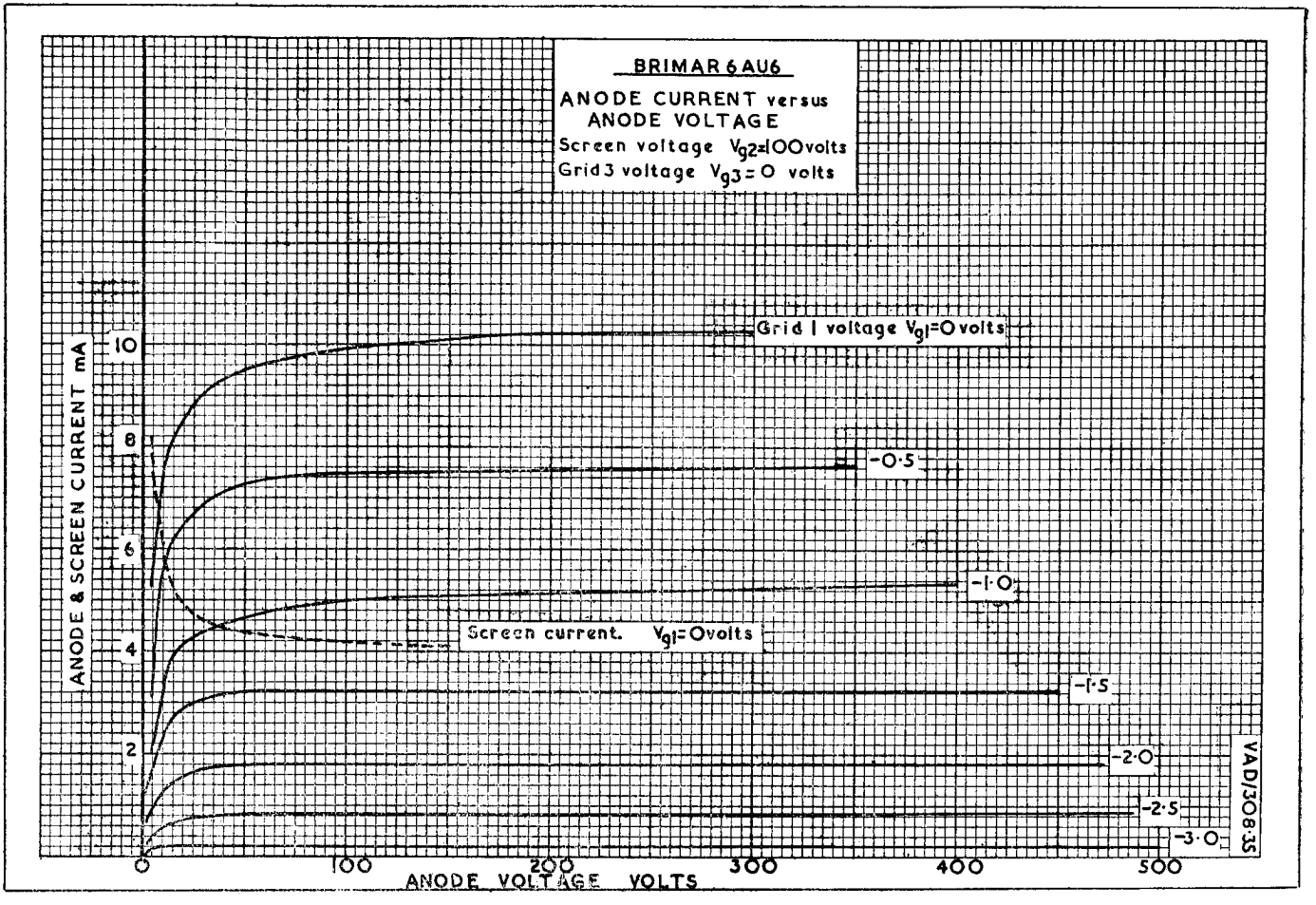

BRIMAR 6AU6
Anode supply voltage $V_{a(b)}$=250volts
Anode load resistor R_a=220kΩ
——Anode current I_a
– – –Screen current I_{g2}
ANODE CURRENT mA
SCREEN CURRENT mA
GRID 1 VOLTAGE V_{g1} VOLTS
Screen voltage V_{g2}=75 volts
60
50
40
30
20
10
V_{g2}=10
100
20
Grid current μA
V_{g1} volts
VAD/308-30

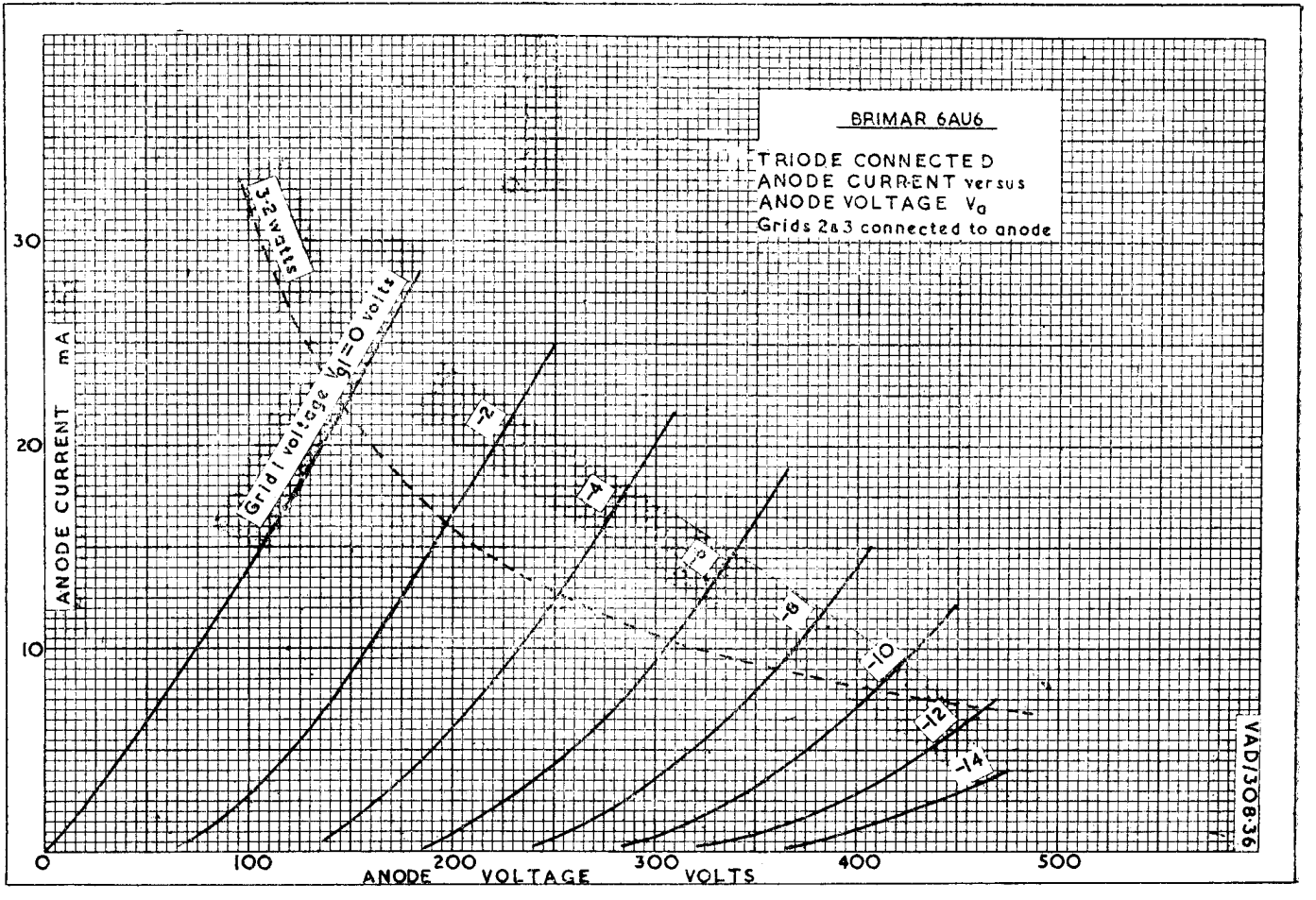

BRIMAR 6AU6
Anode supply voltage $V_{a(b)}$ = 250 volts
Anode load resistor R_a = 100 kΩ
Anode current
Screen current
ANODE CURRENT mA
SCREEN CURRENT mA
GRID 1 VOLTAGE VOLTS
Screen voltage V_{g2} = 75 volts
V_{g2} = 72
Grid current μA
V_{g1} volts
60
50
40
30
20
10
100
3·0
2·5
2·0
1·5
1·0
0·5
0
1·2
1·0
0·8
0·6
0·4
0·2
-4
-3
-2
-1
0
-1·0
31/3/08 VAD

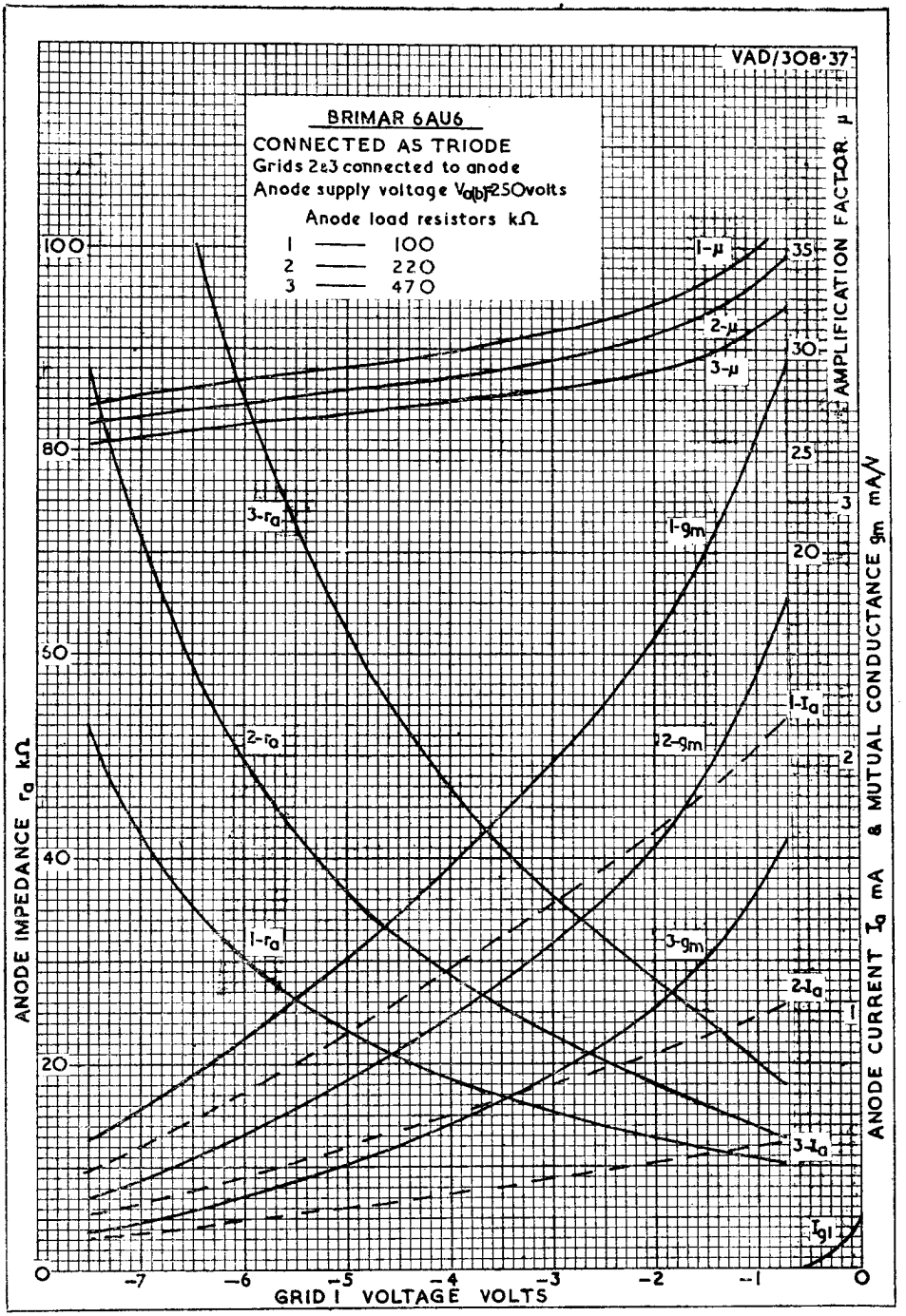

VAD/308·32
BRIMAR 6AU6
ANODE & SCREEN CURRENT
versus GRID 1 VOLTAGE V_{g1}
Anode voltage V_a = 250 volts
Grid 3 voltage V_{g3} = 0 volts
Anode current I_a
Screen current I_{g2}
Screen voltage V_{g2} = 150
100
150
100
50
50
18
16
14
12
10
8
6
4
2
ANODE & SCREEN CURRENT mA
-6
-5
-4
-3
-2
-1
0
GRID 1 VOLTAGE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

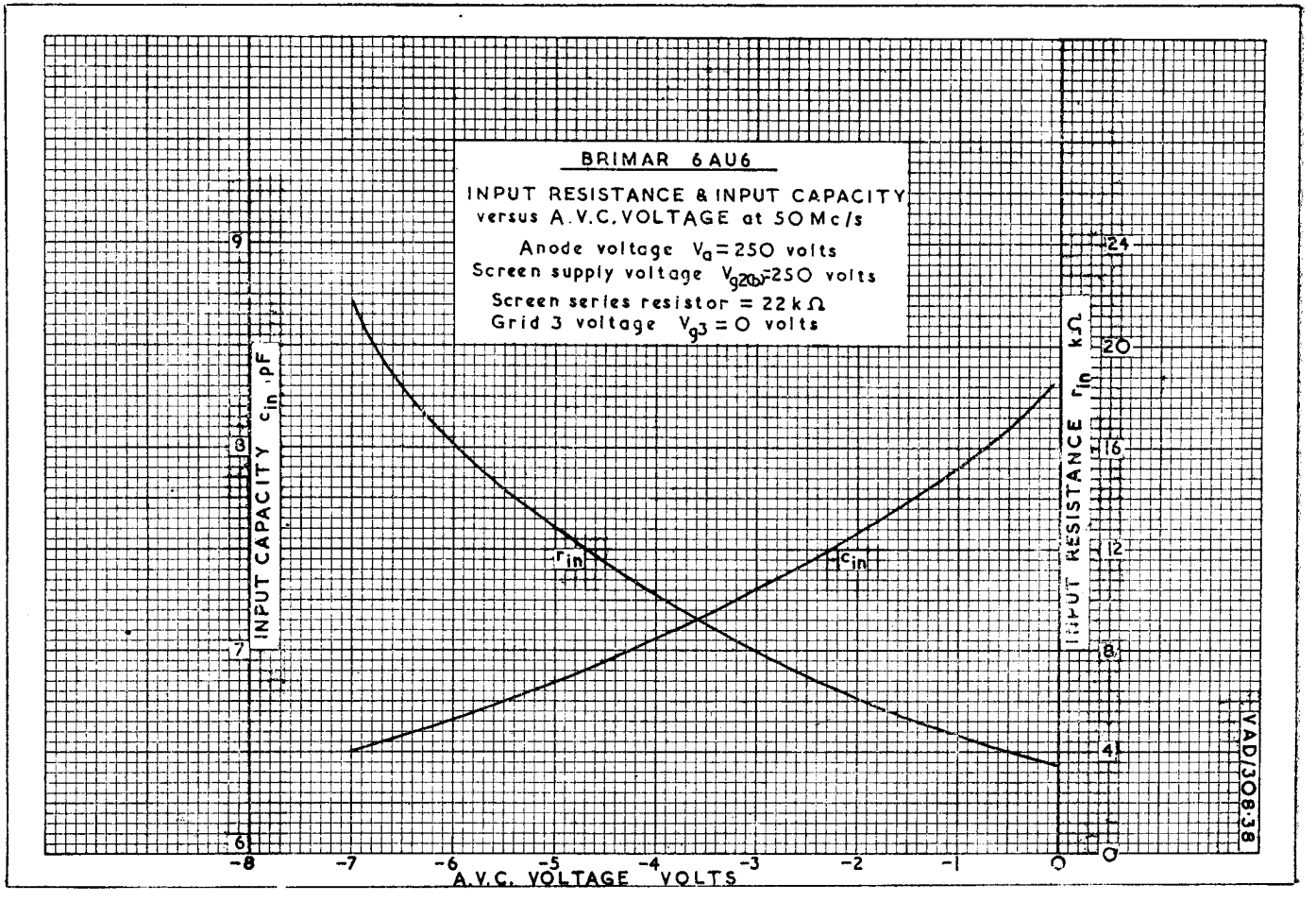

VAD/308-33
BRIMAR 6AU6
ANODE IMPEDANCE &
MUTUAL CONDUCTANCE
versus GRID I VOLTAGE V_{g1}
Anode voltage V_a = 250 volts
Grid 3 voltage V_{g3} = 0 volts
g_m
g_m
g_m
r_a
r_a
r_a
100
150
100
150
50
Screen voltage
V_{g2} = 150 volts
ANODE IMPEDANCE r_a MΩ
MUTUAL CONDUCTANCE g_m mA/V
GRID I VOLTAGE VOLTS
20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

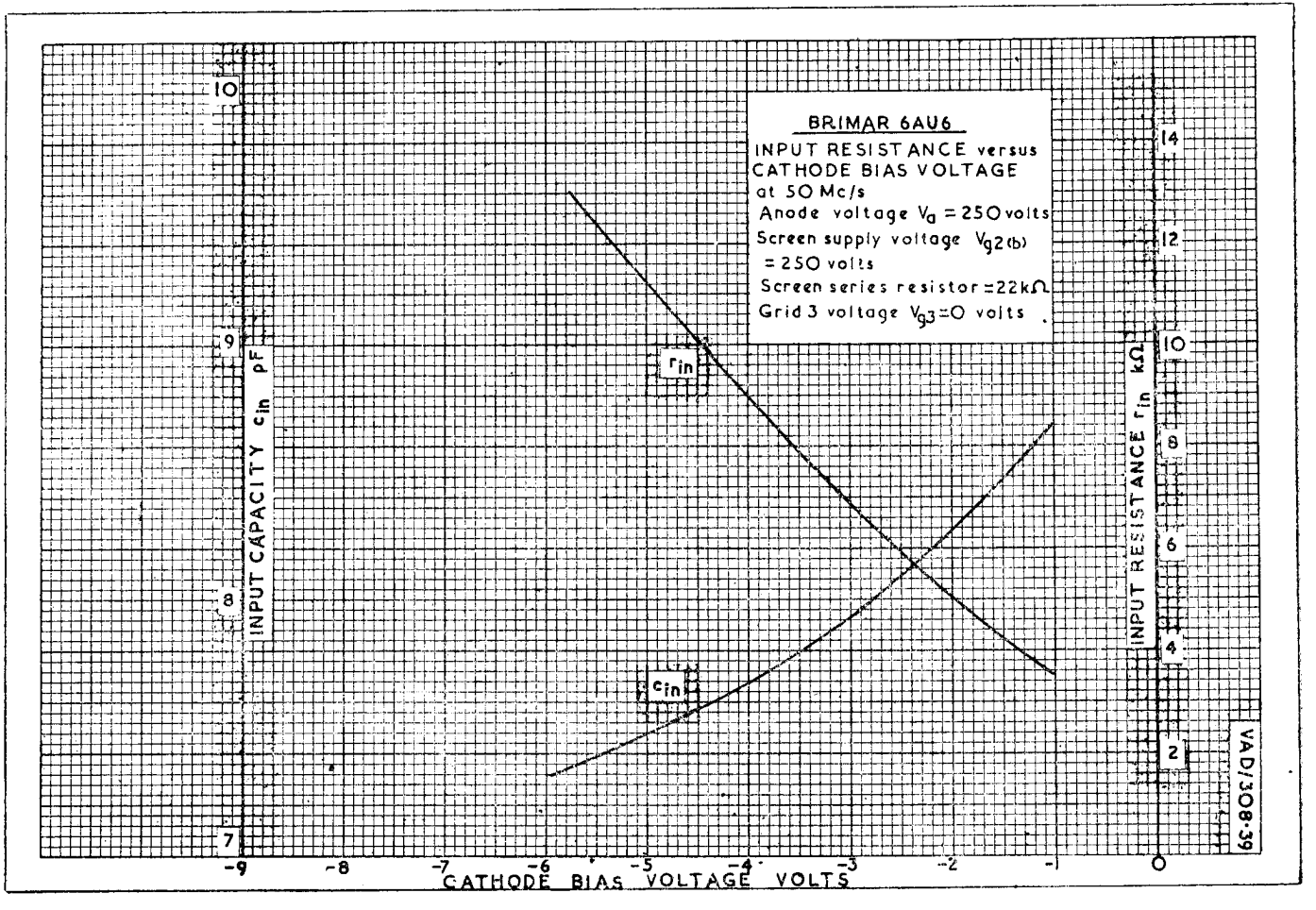

BRIMAR 6AU6
ANODE CURRENT versus
ANODE VOLTAGE
Screen voltage V_{g2}=150volts
Grid 3 voltage V_{g3}=0 volts
Grid 1 voltage V_{g1}=-0·5 volts
0
-1·0
-1·5
-2·0
-2·5
-3·0
-4·0
ANODE CURRENT mA
14
12
10
8
6
4
2
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VA D/308-34


BRIMAR 6AU6
ANODE CURRENT versus
ANODE VOLTAGE
Screen voltage V_{g2}=100volts
Grid 3 voltage V_{g3} = 0 volts
Grid 1 voltage V_{g1}=0volts
-0·5
-1·0
-1·5
-2·0
-2·5
-3·0
Screen current. V_{g1}=0volts
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 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 $V_{a(b)}$=250volts
Anode load resistors kΩ
1 —— 100
2 —— 220
3 —— 470
1-μ
2-μ
3-μ
1-ra
2-ra
3-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
100
80
60
40
20
35
30
25
20
15
10
5
0
−7
−6
−5
−4
−3
−2
−1
0


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
A.V.C. VOLTAGE VOLTS
r_{in}
c_{in}
9
8
7
6
24
20
16
12
8
4
0
-8
-7
-6
-5
-4
-3
-2
-1
0
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
r_{in}
c_{in}
INPUT CAPACITY c_{in} pF
INPUT RESISTANCE r_{in} kΩ
CATHODE BIAS VOLTAGE VOLTS
10
9
8
7
14
12
10
8
6
4
2
0
-9
-8
-7
-6
-5
-4
-3
-2
-1
VAD/308-39

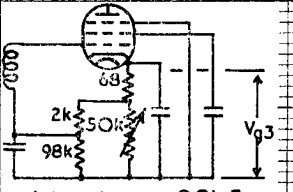
BRIMAR 6AU6

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

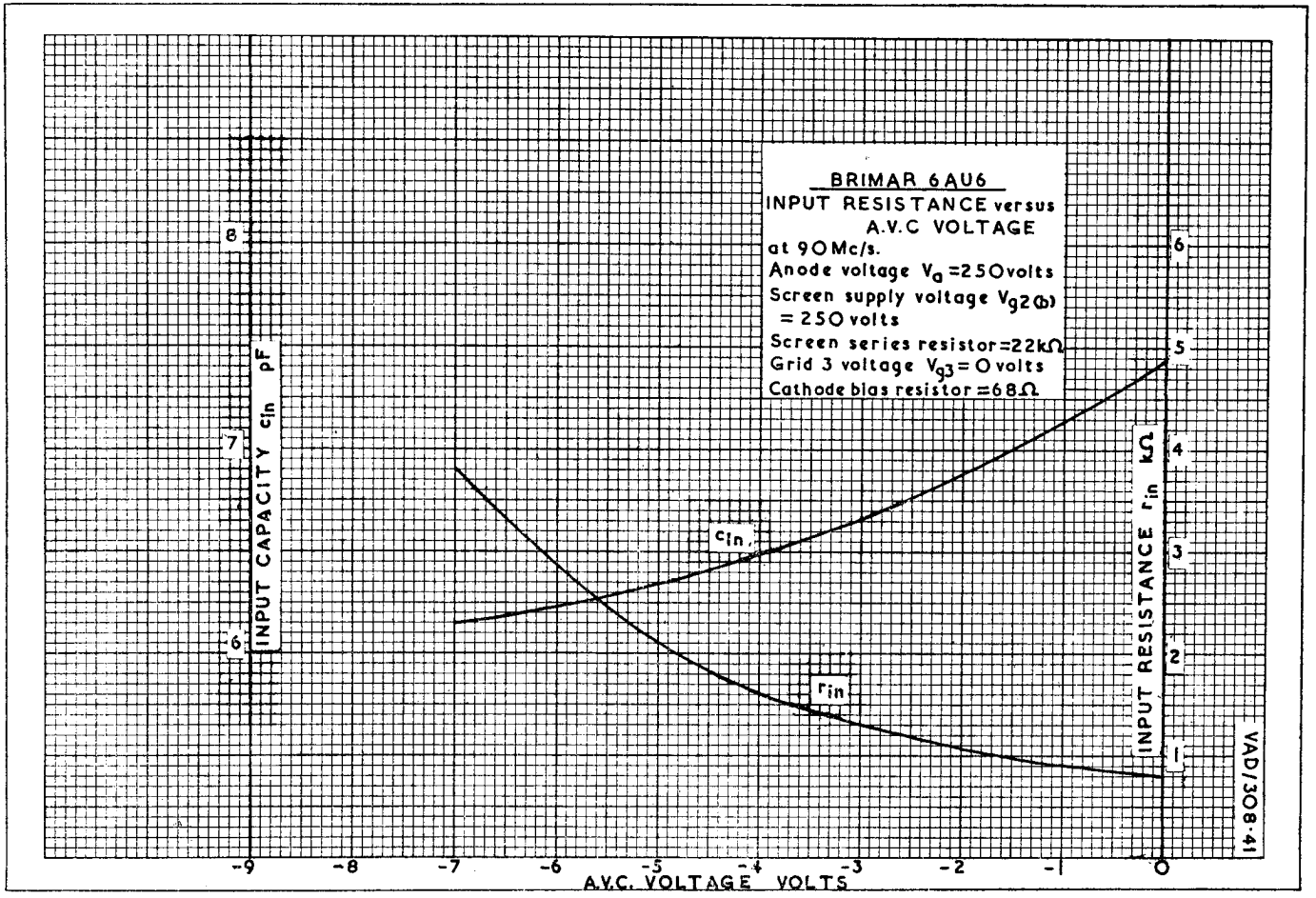
C_{in}

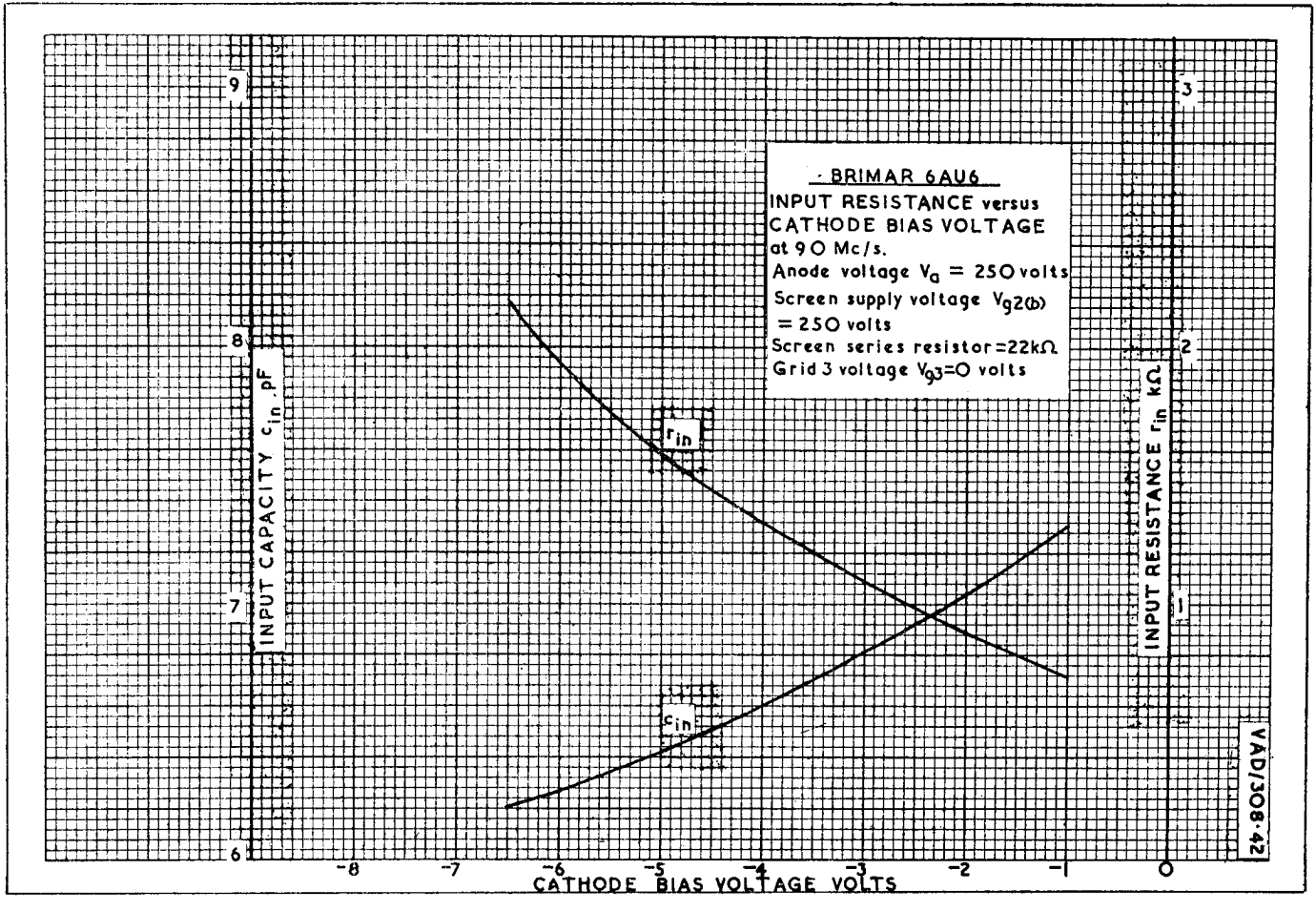
r_{in}

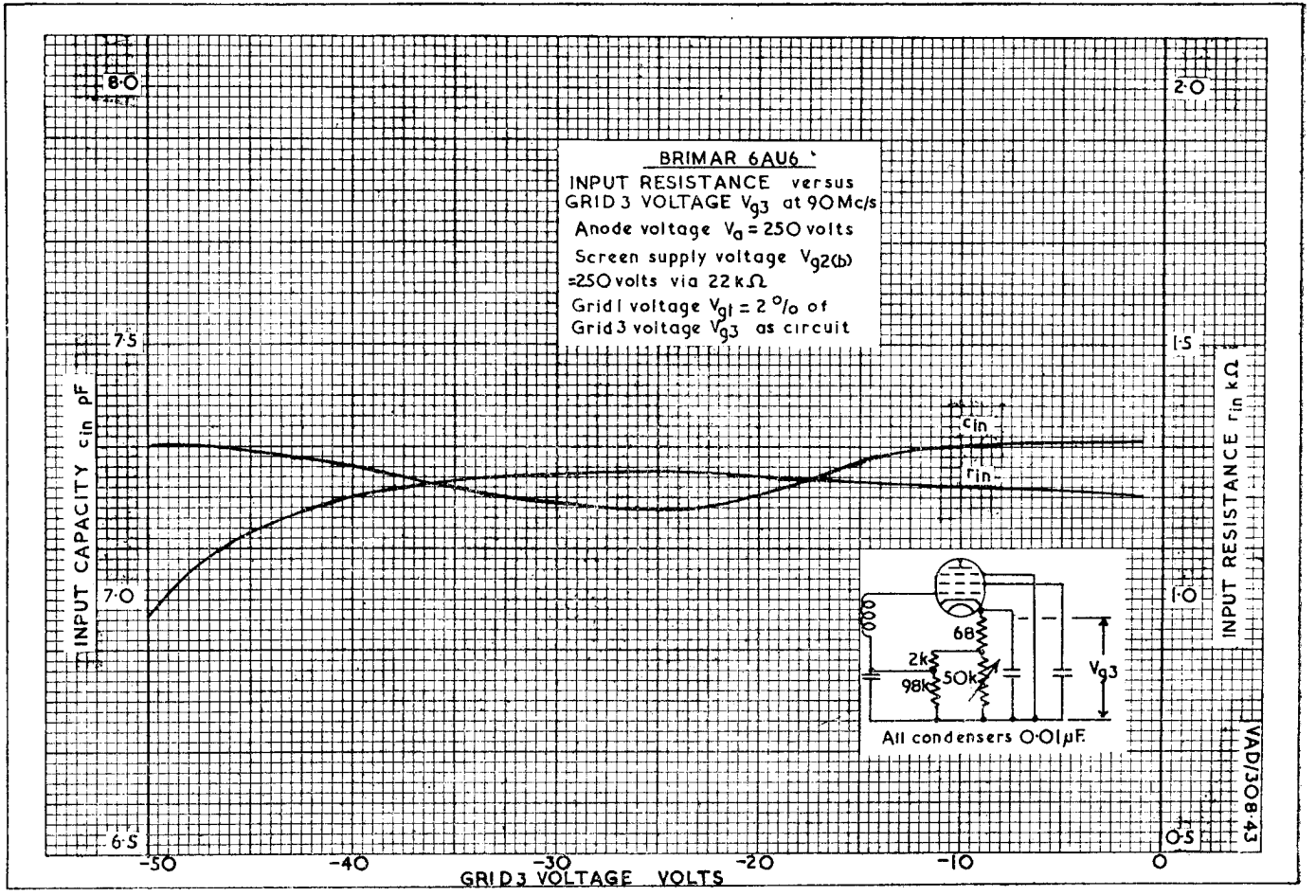
−50 −40 −30 −20 −10 0

GRID 3 VOLTAGE VOLTS

VAD/308·40


BRIMAR 6AU6
INPUT RESISTANCE versus A.V.C VOLTAGE
at 90Mc/s.
Anode voltage V_a = 250volts
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
c_{in}
r_{in}
INPUT RESISTANCE r_{in} kΩ
6
5
4
3
2
1
-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 V_a = 250 volts
Screen supply voltage $V_{g2(b)}$
= 250 volts
Screen series resistor = 22kΩ
Grid 3 voltage V_{g3} = 0 volts
r_{in}
c_{in}
INPUT CAPACITY c_{in} pF
INPUT RESISTANCE r_{in} kΩ
CATHODE BIAS VOLTAGE VOLTS
9
8
7
6
3
2
1
0
-8
-7
-6
-5
-4
-3
-2
-1
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
8·0
7·5
7·0
6·5
INPUT CAPACITY cin pF
2·0
1·5
1·0
0·5
INPUT RESISTANCE rin kΩ
cin
rin
68
2k
98k
50k
V_{g3}
All condensers 0·01μF
-50
-40
-30
-20
-10
0
GRID 3 VOLTAGE VOLTS
VAD/C/0843

BRIMAR 6AU6

F.M. LIMITER OPERATION

I.F. 10·7 Mc/s.

R.M.S. INPUT VOLTAGE VOLTS

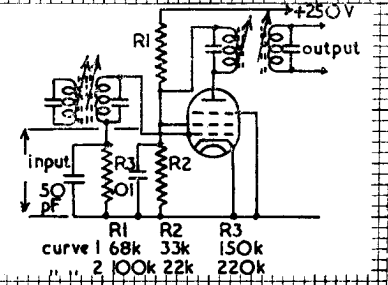
14
12
10
8
6
4
2

curve 1

curve 2

0 2 4 6 8 10 12 14 16 18 20

R.M.S. OUTPUT VOLTAGE VOLTS



VAD/308·46

BRIMAR

RECEIVING VALVE

6BA6

APPLICATION REPORT VAD/509.2

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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:

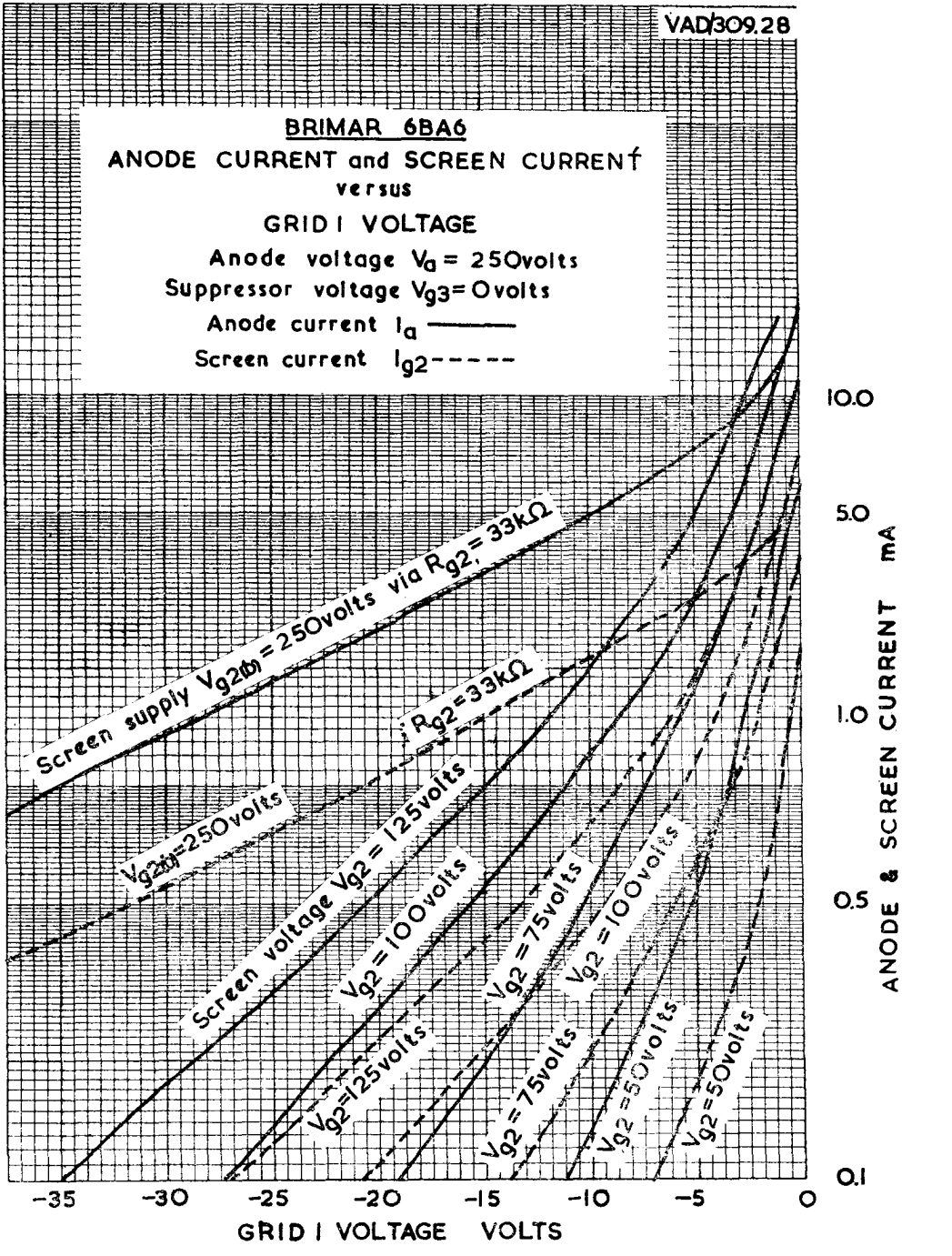
$$\frac{250 - 30}{0{\cdot}28} \times 1000, \text{ or } 785{,}000 \text{ ohms.}$$

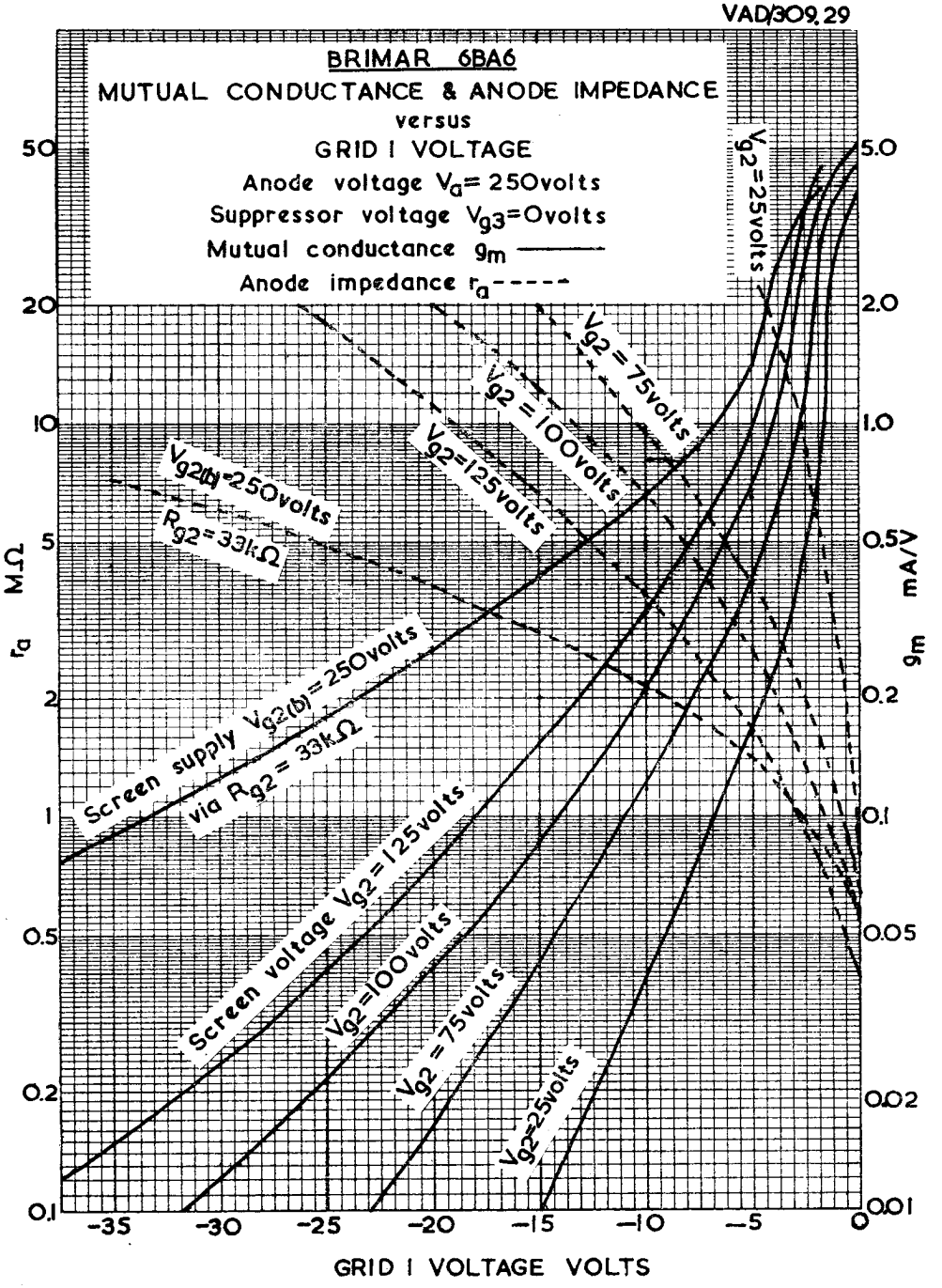
Again the nearest preferred value would be 680,000 ohms. If the grid has a peak AF input of ±0·5 volts as a maximum, the anode current will vary from 0·60 mA at a grid voltage of —2·0 volts to 1·07 mA at —1 volt, hence a change of 0·47 mA in 220,000 is 104 volts peak-peak. This is an output of 52 volts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

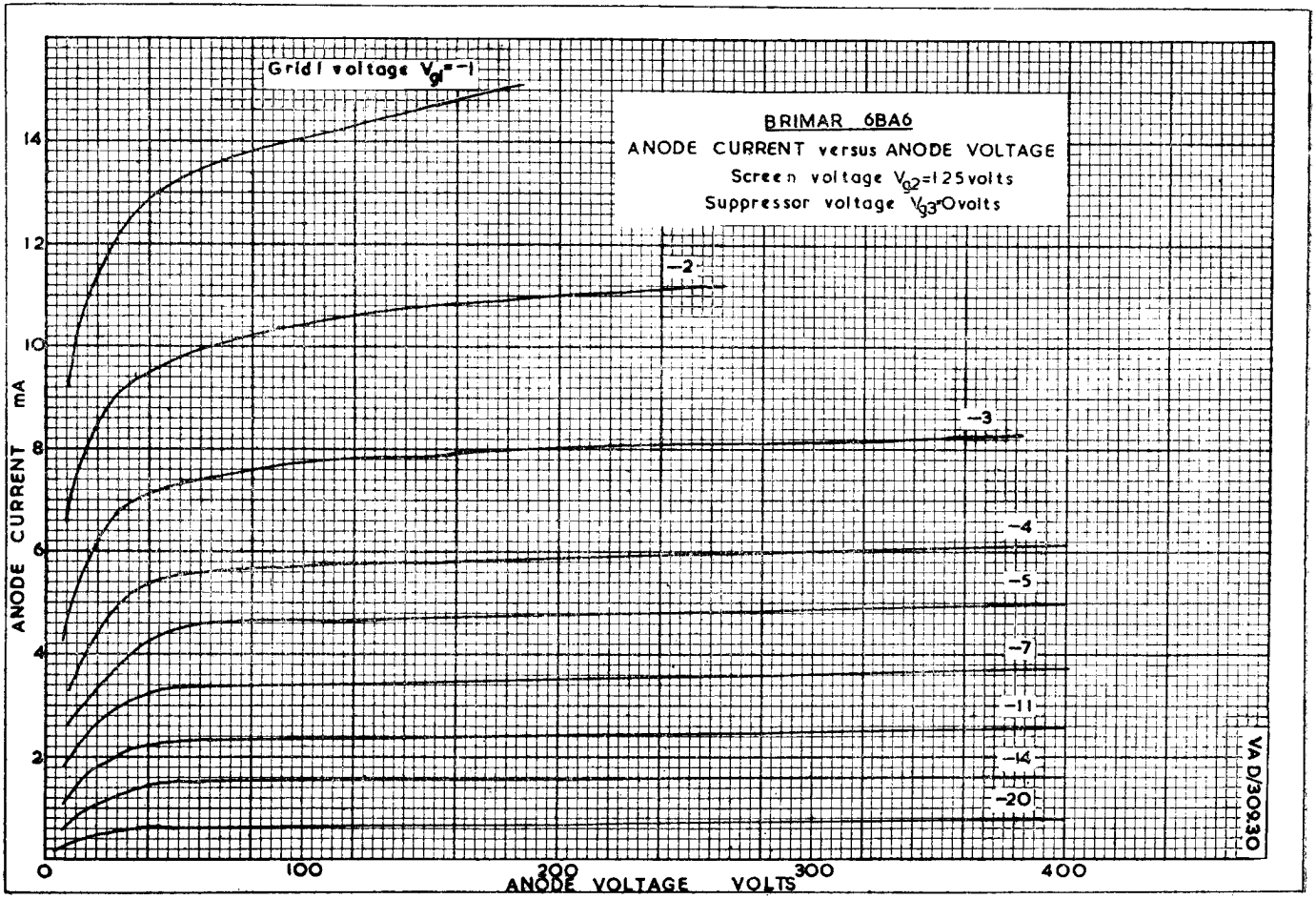
As allowance must be made for the succeeding valve grid leak the above values will be reduced by a factor of:

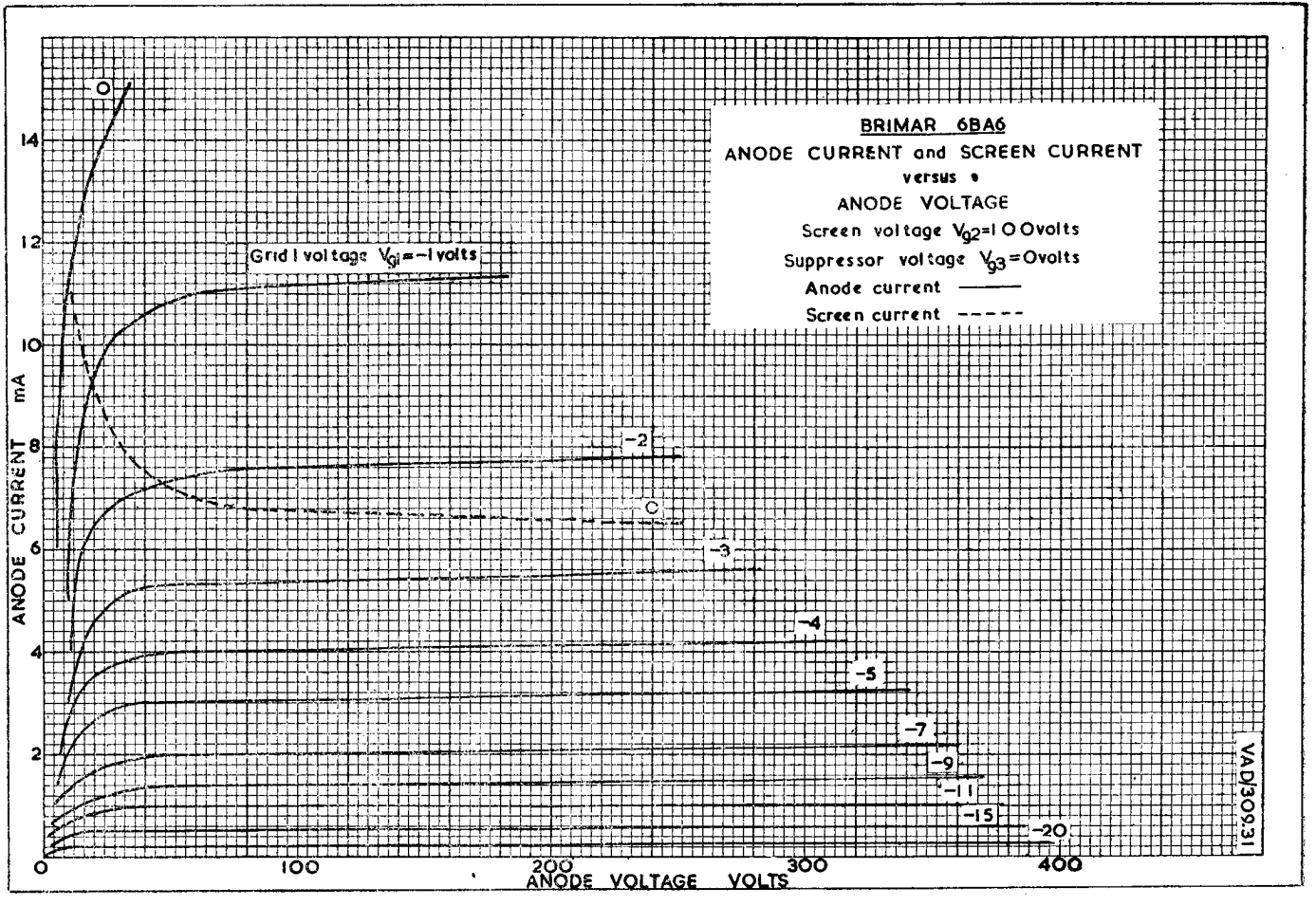
$$\frac{470{,}000}{470{,}000 + 220{,}000} \text{ or } 0{\cdot}68,$$

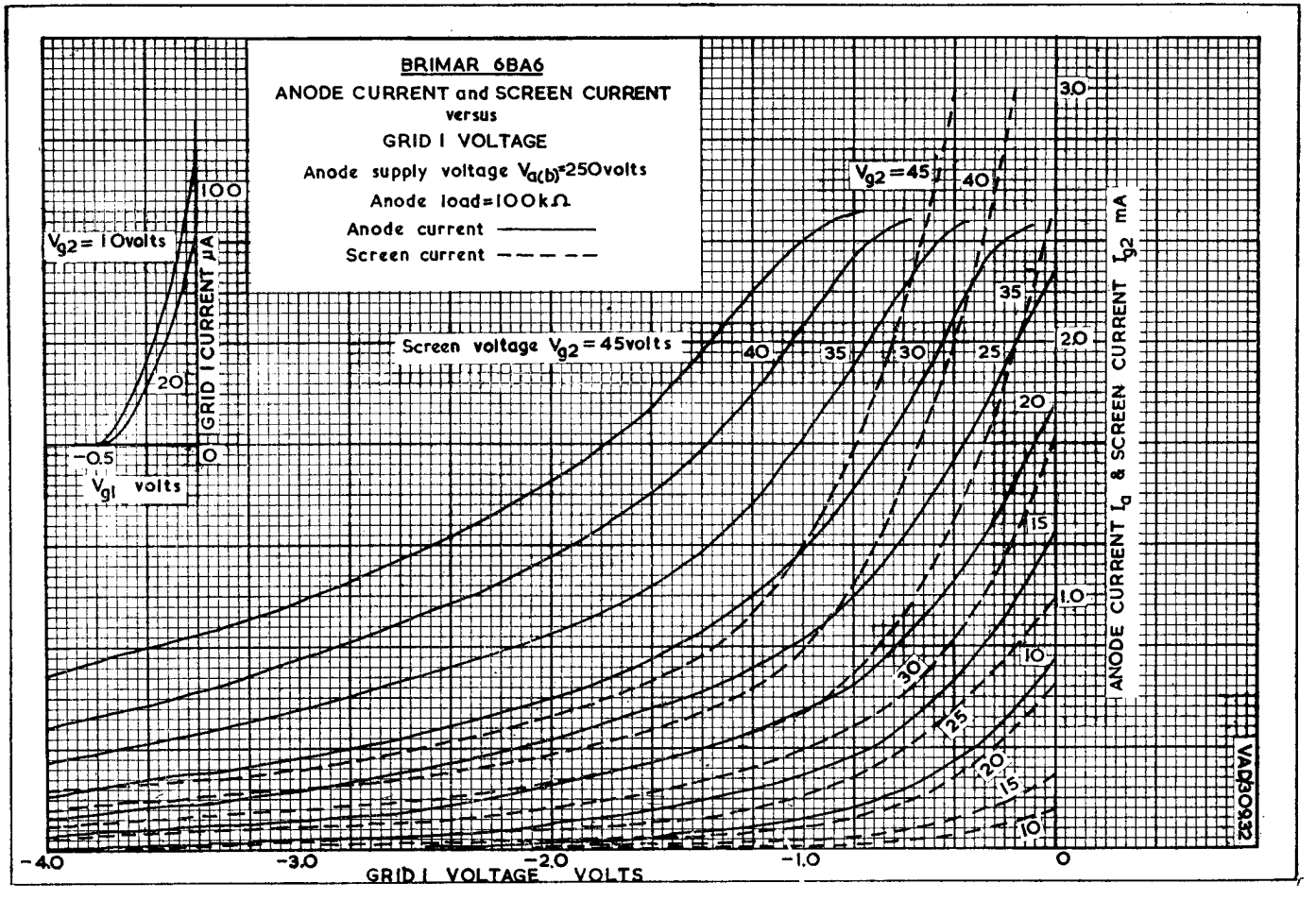
hence the actual operating gain will be 70 and the output voltage 50 volts peak for an input of 0·7 volts peak. An estimate of the distortion can be obtained by calculating in a similar manner the voltage gain for the positive swing (—1·5 to —1·0 volts) and the negative swing (—1·5 to —2·0 volts) separately,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

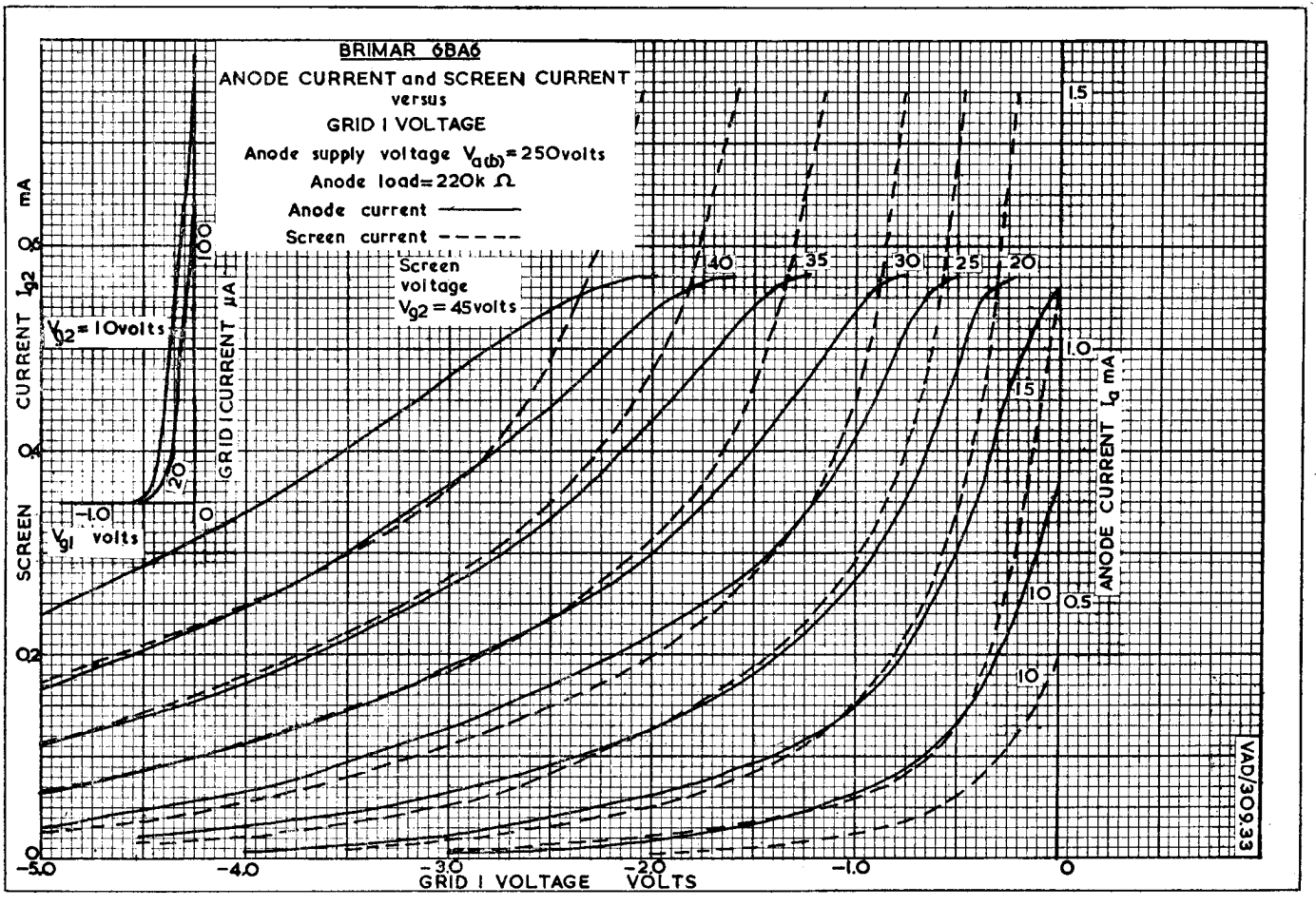

VAD/309.28
BRIMAR 6BA6
ANODE CURRENT and SCREEN CURRENT
versus
GRID 1 VOLTAGE
Anode voltage V_a = 250volts
Suppressor voltage V_{g3} = 0volts
Anode current I_a ———
Screen current I_{g2} - - - - -
Screen supply $V_{g2(b)}$ = 250volts via R_{g2} = 33kΩ
R_{g2} = 33kΩ
$V_{g2(b)}$ = 250volts
Screen voltage V_{g2} = 125volts
V_{g2} = 100volts
V_{g2} = 75volts
V_{g2} = 50volts
V_{g2} = 125volts
V_{g2} = 75volts
V_{g2} = 100volts
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 1 VOLTAGE VOLTS

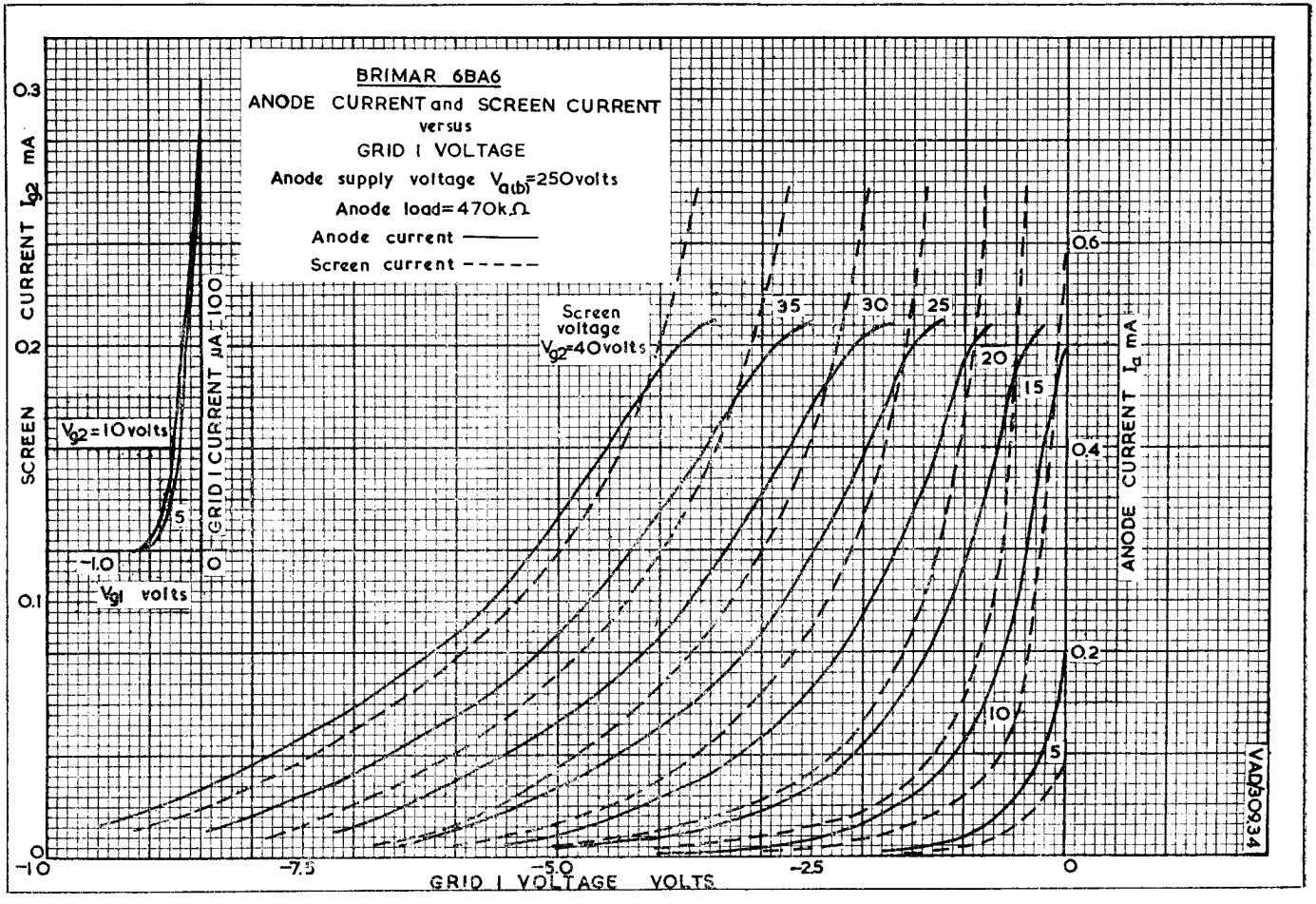

BRIMAR 6BA6
MUTUAL CONDUCTANCE & ANODE IMPEDANCE
versus
GRID 1 VOLTAGE
Anode voltage V_a = 250volts
Suppressor voltage V_{g3} = 0volts
Mutual conductance g_m ——
Anode impedance r_a - - - -
V_{g2} = 25volts
V_{g2} = 75volts
V_{g2} = 100volts
V_{g2} = 125volts
$V_{g2(b)}$ = 250volts
R_{g2} = 33kΩ
Screen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

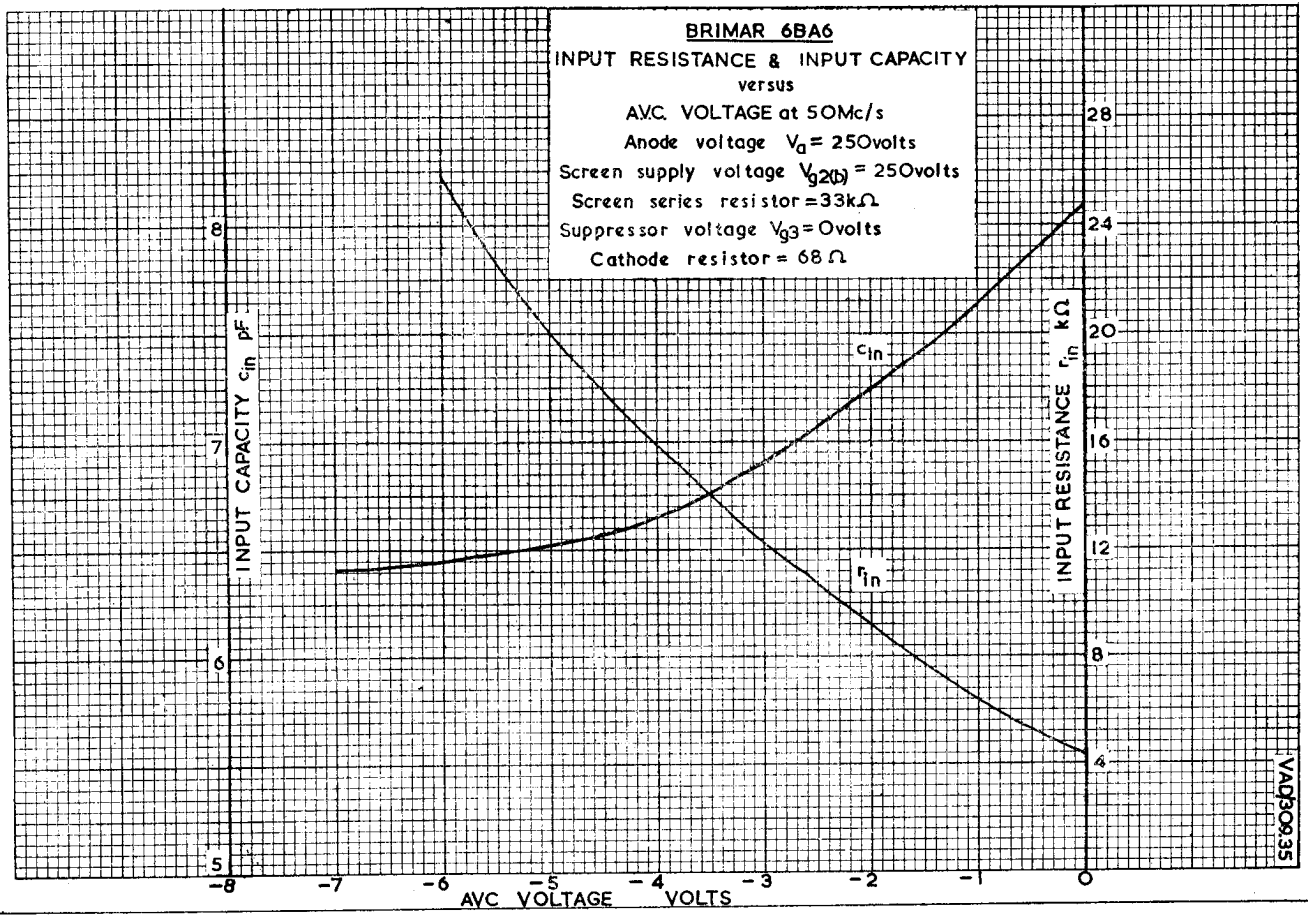

BRIMAR 6BA6
ANODE CURRENT versus ANODE VOLTAGE
Screen voltage V_{g2}=125volts
Suppressor voltage V_{g3}=0volts
Grid voltage V_{g1}=-1
-2
-3
-4
-5
-7
-11
-14
-20
ANODE CURRENT mA
ANODE VOLTAGE VOLTS
0
100
200
300
400
2
4
6
8
10
12
14
VA D/309.30

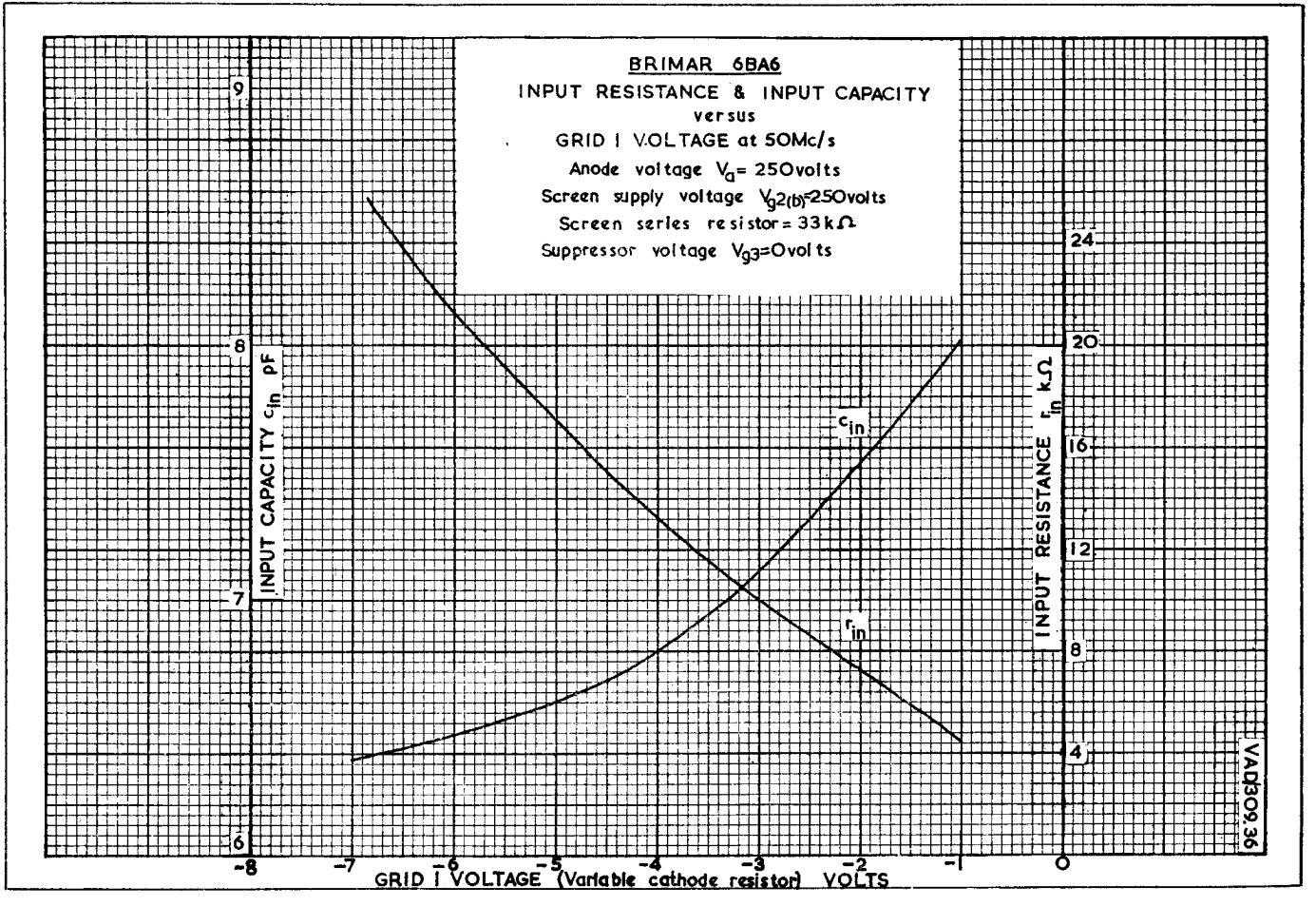

BRIMAR 6BA6
ANODE CURRENT and SCREEN CURRENT
versus
ANODE VOLTAGE
Screen voltage V_{g2}=100volts
Suppressor voltage V_{g3}=0volts
Anode current
Screen current
Grid 1 voltage V_{g1}=-1volts
0
-2
C
-3
-4
-5
-7
-9
-11
-15
-20
ANODE CURRENT mA
ANODE VOLTAGE VOLTS
0
100
200
300
400
2
4
6
8
10
12
14
VAD/309.31

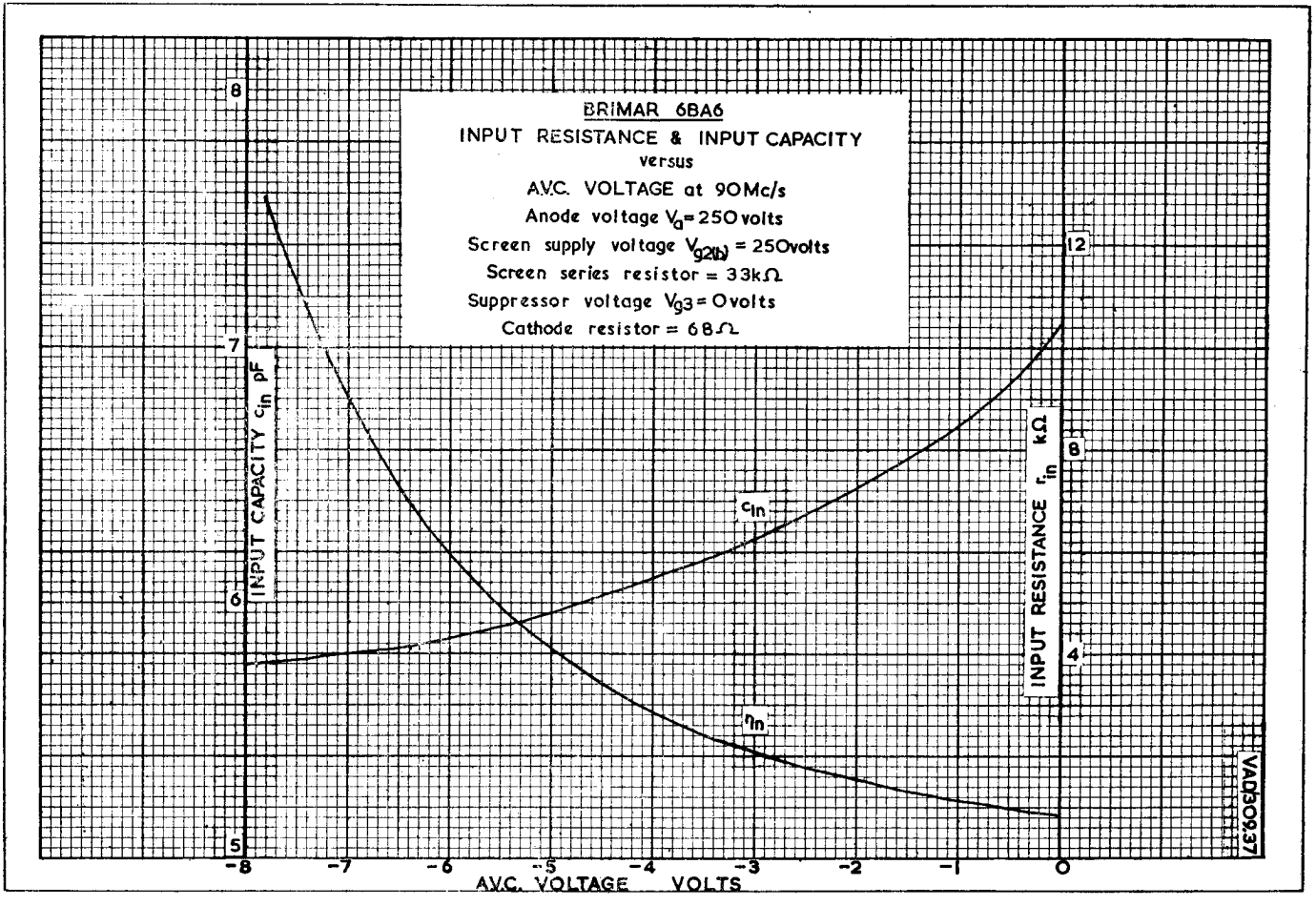

BRIMAR 6BA6
ANODE CURRENT and SCREEN CURRENT
versus
GRID 1 VOLTAGE
Anode supply voltage $V_{a(b)}$=250volts
Anode load=100kΩ
Anode current
Screen current
V_{g2} = 10volts
100
20
0
GRID 1 CURRENT µA
-0.5
V_{g1} volts
Screen voltage V_{g2} = 45volts
V_{g2} = 45
40
35
30
25
20
15
10
3.0
2.0
1.0
ANODE CURRENT I_a & SCREEN CURRENT I_{g2} mA
VAD0932
-4.0
-3.0
-2.0
-1.0
0
GRID 1 VOLTAGE VOLTS

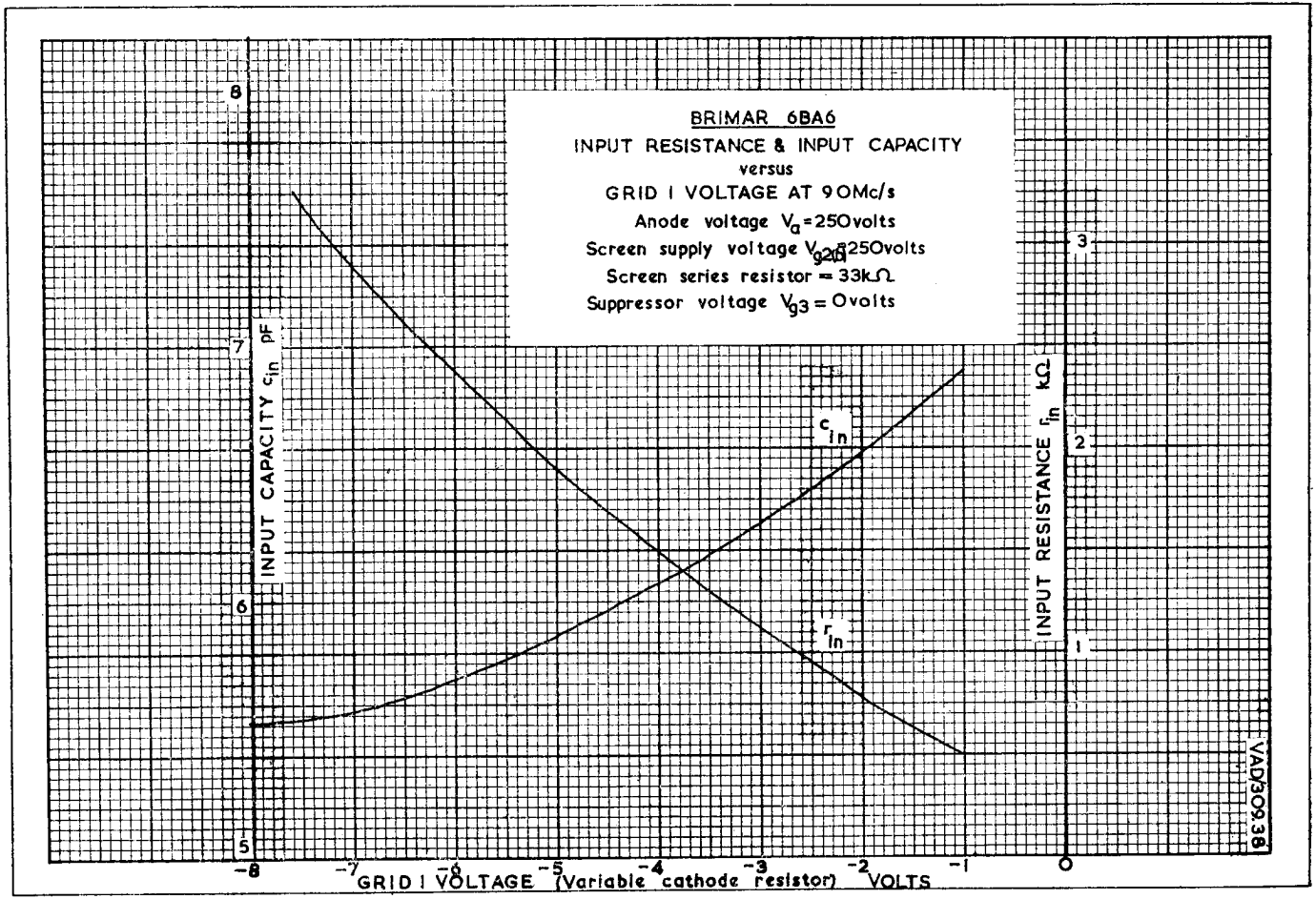

BRIMAR 6BA6
ANODE CURRENT and SCREEN CURRENT
versus
GRID 1 VOLTAGE
Anode supply voltage $V_{a(b)}$ = 250volts
Anode load = 220k Ω
Anode current
Screen current
Screen voltage V_{g2} = 45volts
V_{g2} = 10volts
GRID CURRENT μA
100
20
0
-1.0
V_{g1} volts
SCREEN CURRENT I_{g2} mA
0.8
0.4
0.2
0
40
35
30
25
20
15
10
1.5
1.0
0.5
ANODE CURRENT I_a mA
-5.0
-4.0
-3.0
-2.0
-1.0
0
GRID 1 VOLTAGE VOLTS
VAD/30933


BRIMAR 6BA6
ANODE CURRENT and SCREEN CURRENT
versus
GRID 1 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
5
-1.0
V_{g1} volts
SCREEN CURRENT I_{g2} mA
0.3
0.2
0.1
0
GRID 1 CURRENT μA 100
0
ANODE CURRENT I_a mA
0.6
0.4
0.2
-10
-7.5
-5.0
-2.5
0
GRID 1 VOLTAGE VOLTS
VA0309.34


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 = 68Ω
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
VAD309.35


BRIMAR 6BA6
INPUT RESISTANCE & INPUT CAPACITY
versus
GRID 1 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 1 VOLTAGE (Variable cathode resistor) VOLTS
VAD309.36


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
VAD309.37

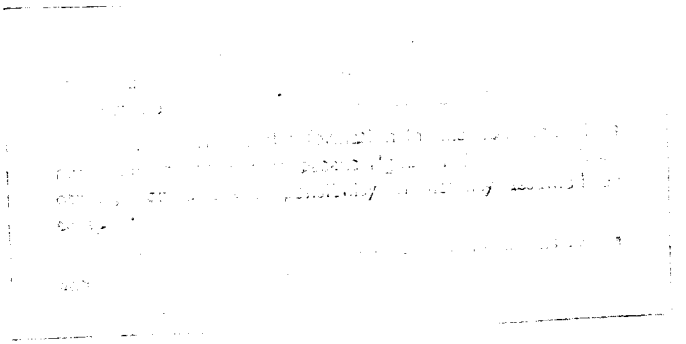

BRIMAR 6BA6
INPUT RESISTANCE & INPUT CAPACITY
versus
GRID 1 VOLTAGE AT 90Mc/s
Anode voltage V_a = 250volts
Screen supply voltage $V_{g2(b)}$ = 250volts
Screen series resistor = 33kΩ
Suppressor voltage V_{g3} = 0volts
INPUT CAPACITY c_{in} pF
INPUT RESISTANCE r_{in} kΩ
c_{in}
r_{in}
8
7
6
5
3
2
1
−8
−7
−6
−5
−4
−3
−2
−1
0
GRID 1 VOLTAGE (Variable cathode resistor) VOLTS
VAD309.3B

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.

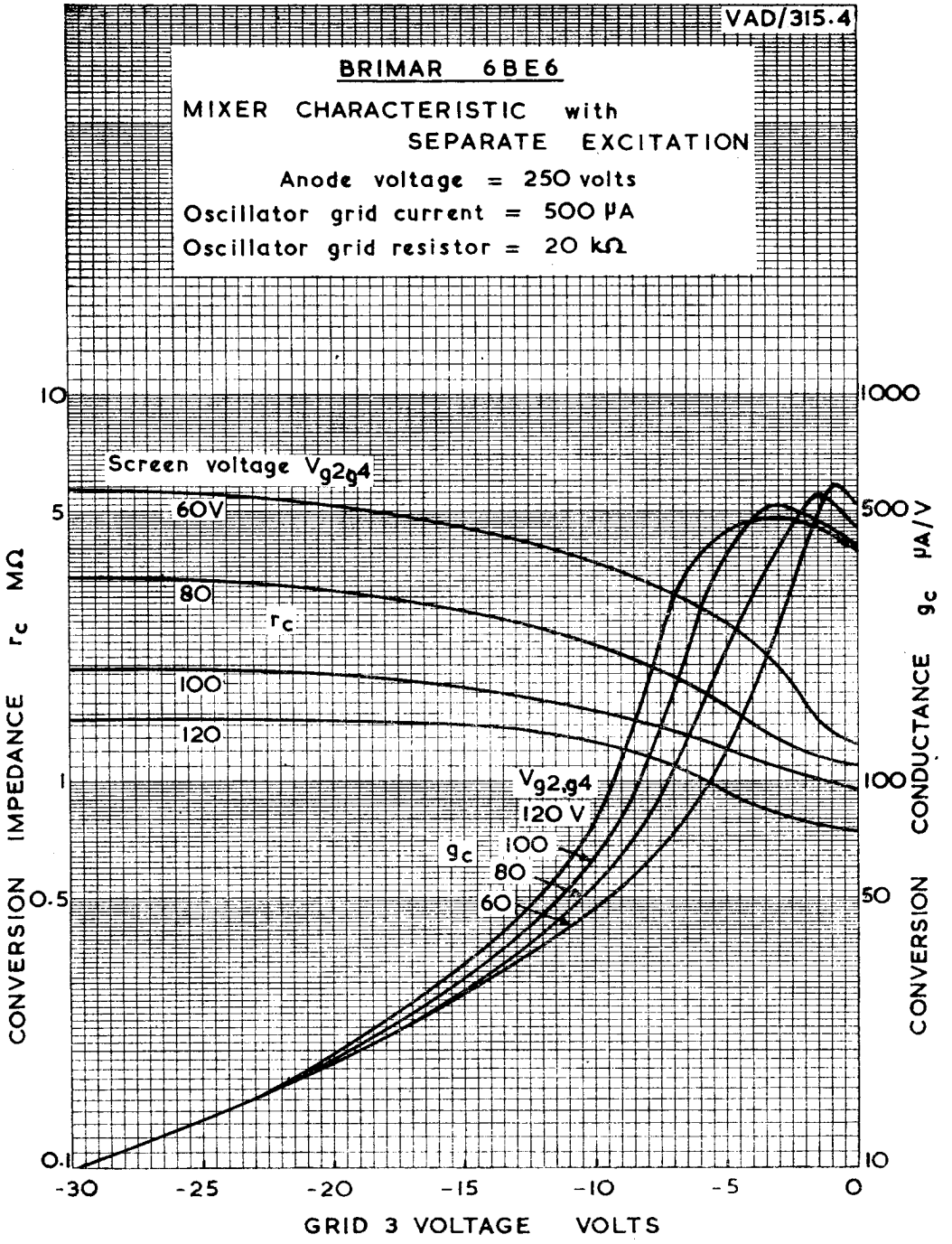
Curves showing the conversion gain and oscillator grid current using the specified coils over the various wavebands are covered on Curves Nos. 315·15, 315·16 and 315·17.

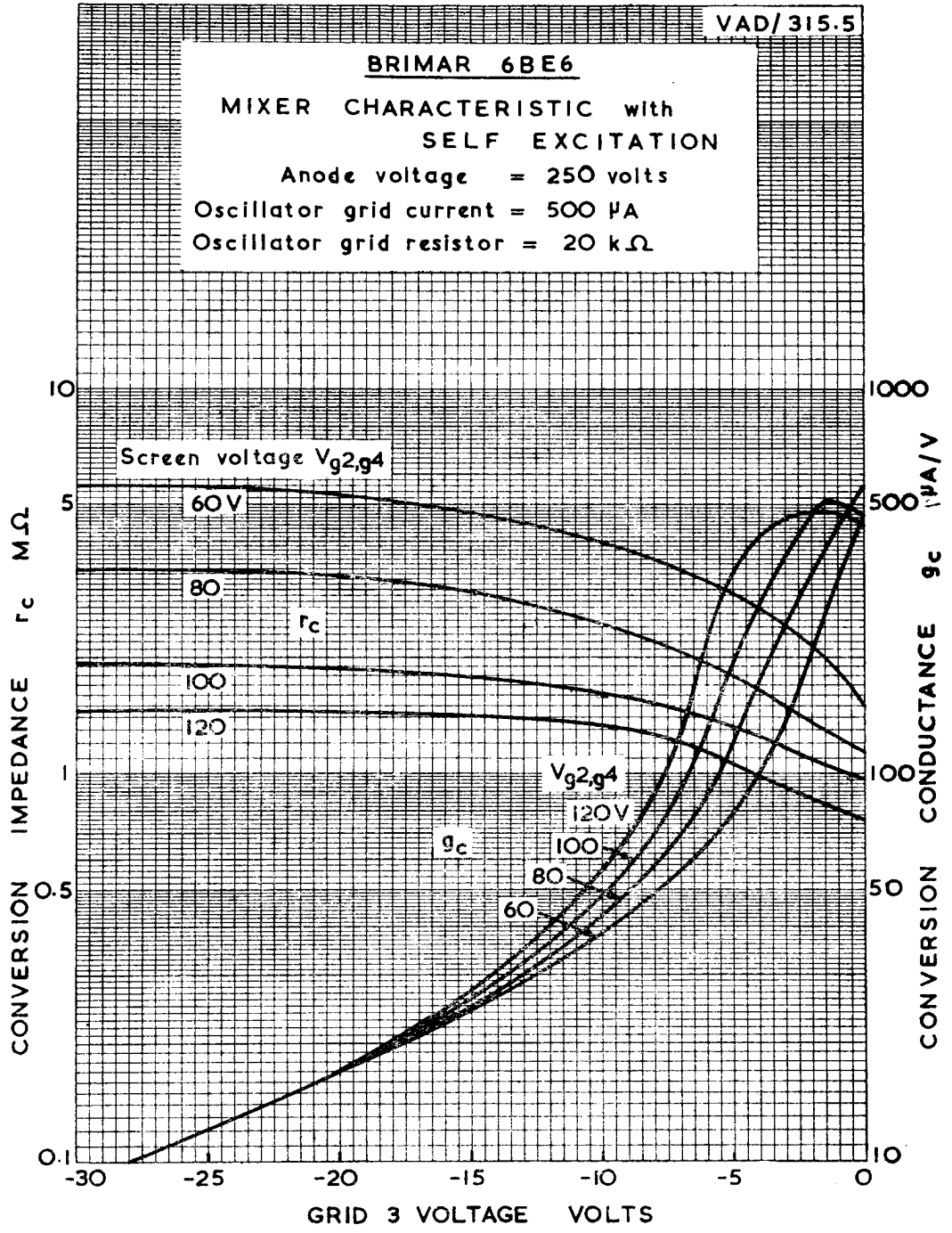
OPERATION AS AN AF MIXER OR IN VOLUME EXPANSION OR CONTRACTION CIRCUITS

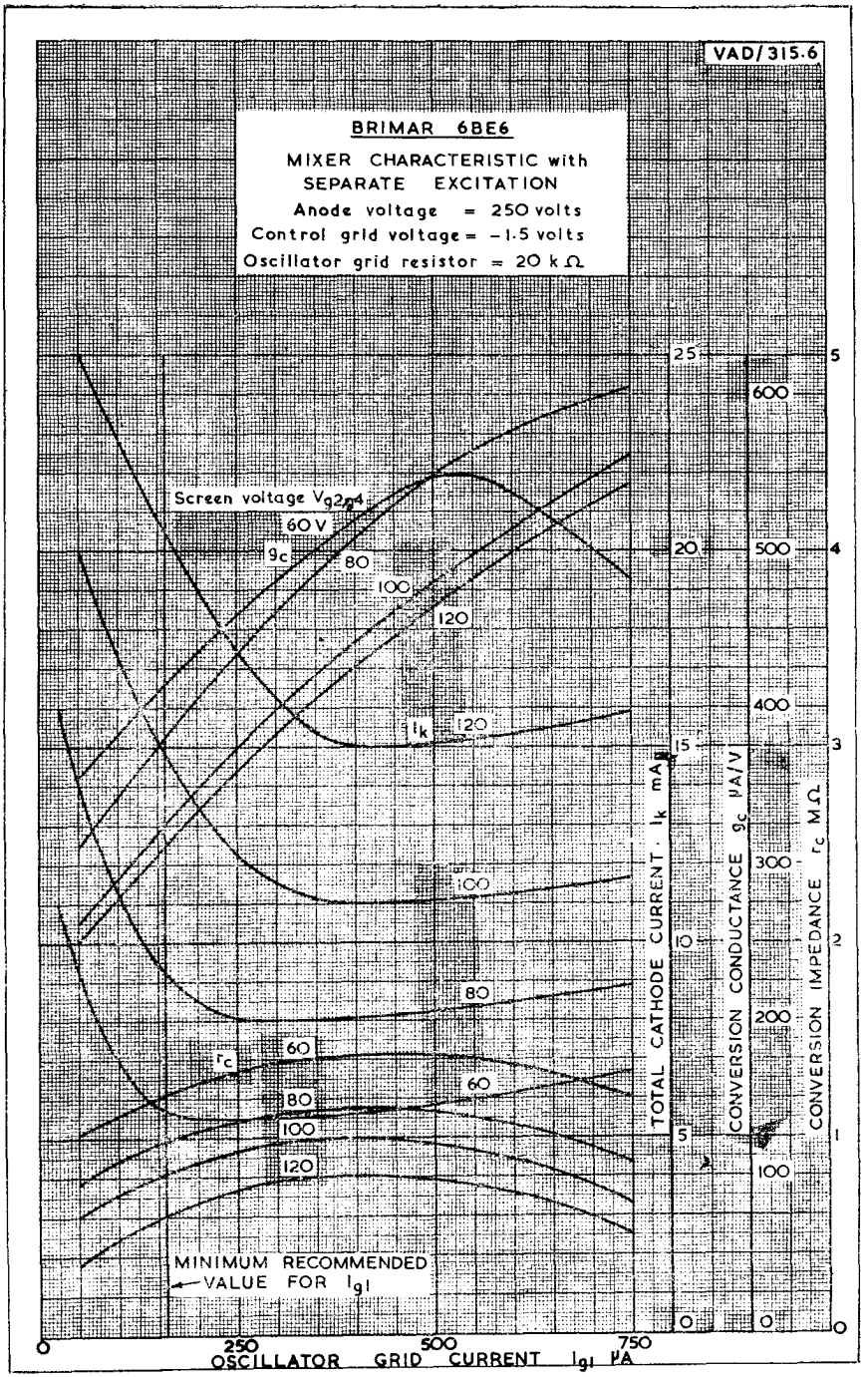
As the valve has two grids capable of being used to control the anode current it is quite suitable for use as an AF mixer or one or other of the grids can be controlled by a DC bias.

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 V_{g2g4}
60V
80
100
120
r_c
$V_{g2,g4}$
120 V
100
80
60
g_c
10
5
1
0.5
0.1
1000
500
100
50
10
-30
-25
-20
-15
-10
-5
0
CONVERSION IMPEDANCE r_c MΩ
CONVERSION CONDUCTANCE g_c 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
CONVERSION IMPEDANCE rc MΩ
CONVERSION CONDUCTANCE gc μA/V
-30
-25
-20
-15
-10
-5
0
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 V_{g2g4}
60 V
g_c
80
100
120
I_k
120
100
80
r_c
60
80
100
120
60
MINIMUM RECOMMENDED
← VALUE FOR I_{g1}
TOTAL CATHODE CURRENT I_k mA
CONVERSION CONDUCTANCE g_c μA/V
CONVERSION IMPEDANCE r_c MΩ
OSCILLATOR GRID CURRENT I_{g1} μA
0
250
500
750
25
20
15
10
5
0
600
500
400
300
200
100
0
5
4
3
2
1
0

VAD/315.7

BRIMAR 6BE6

MIXER CHARACTERISTIC with SELF EXCITATION

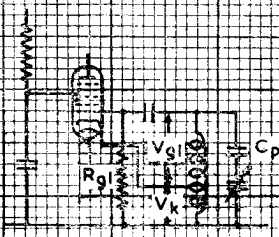
Anode voltage = 250 volts

Screen voltage = 100 volts

Control grid voltage = −1 volt

Oscillator grid resistor = 20 kΩ

P = Percentage Ratio V_k(rms) to V_{g1}(rms)+V_k(rms)



V_k(rms)=0.8 volts

P=5%

1.4

10%

2.0

3.0

20%

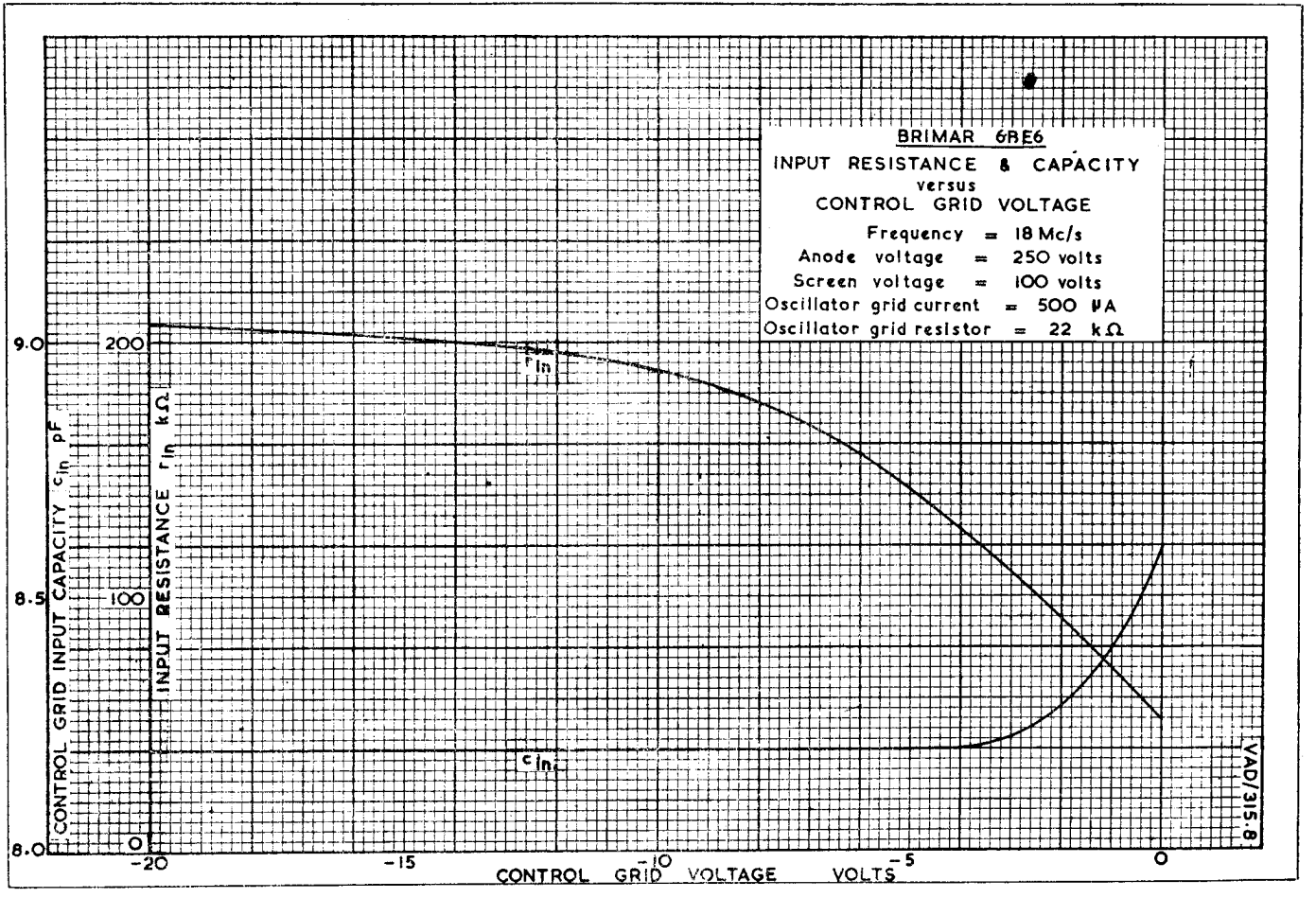
5.0

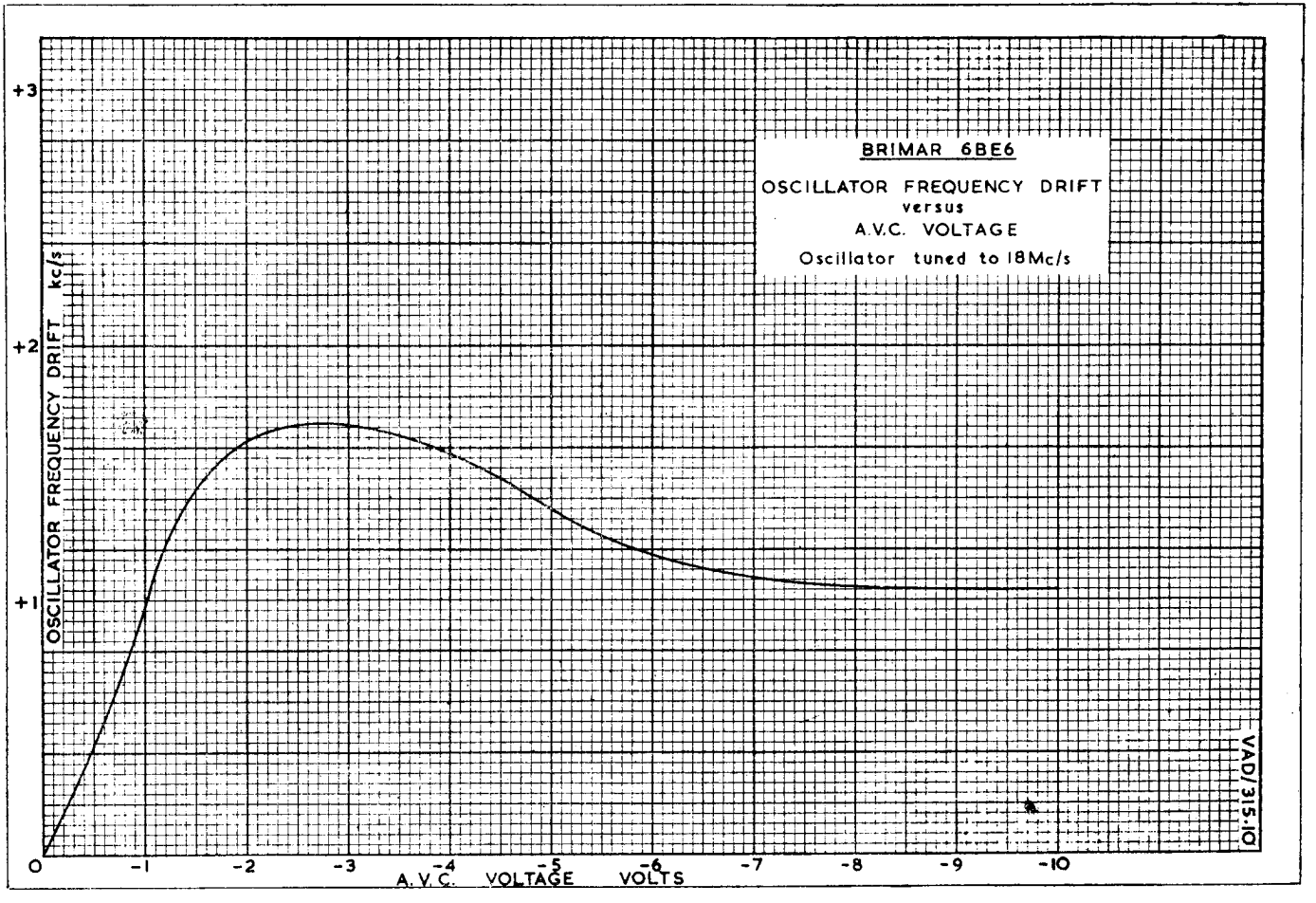
CONVERSION CONDUCTANCE μA/V

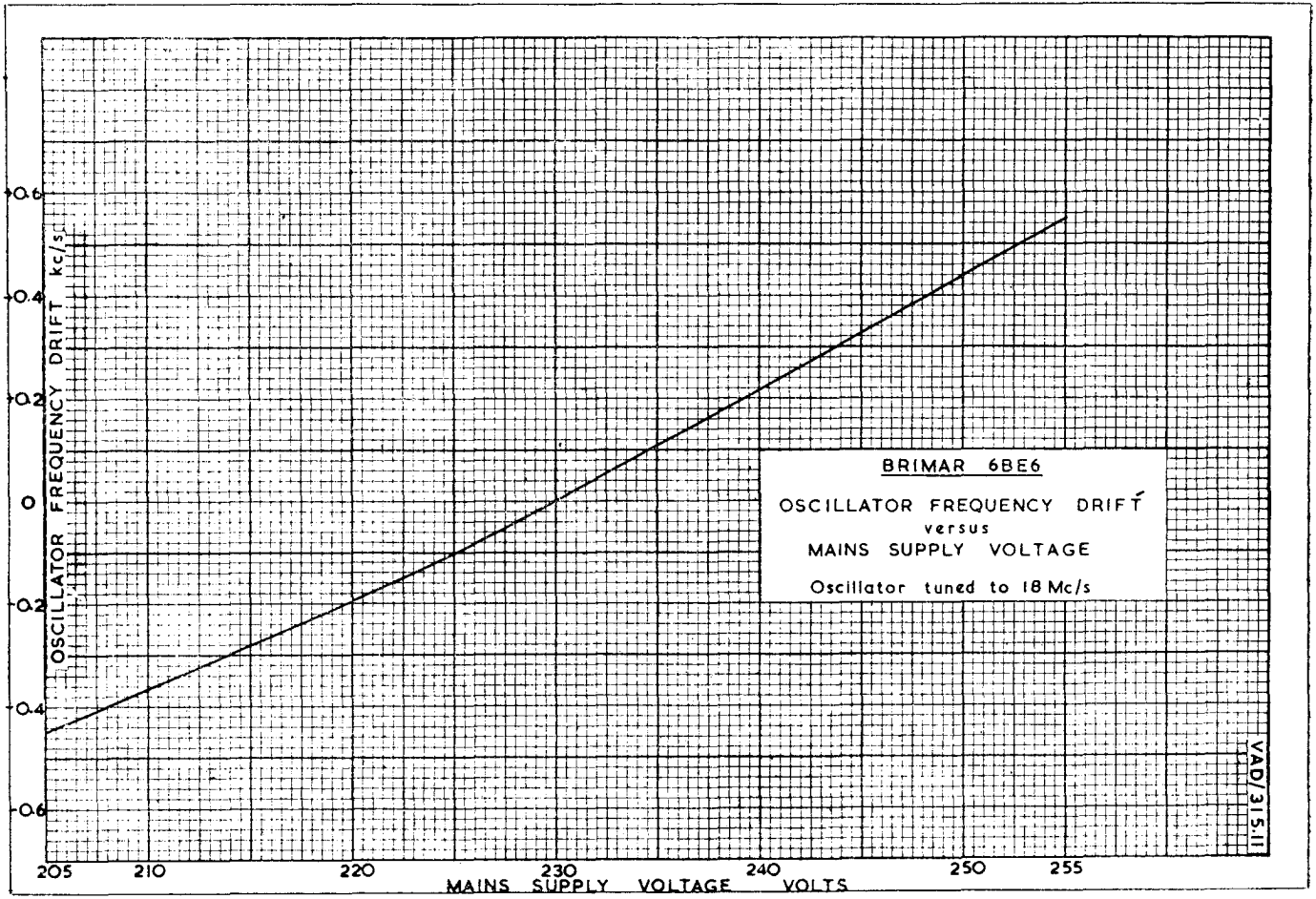
700
600
500
400
300
200
100
0

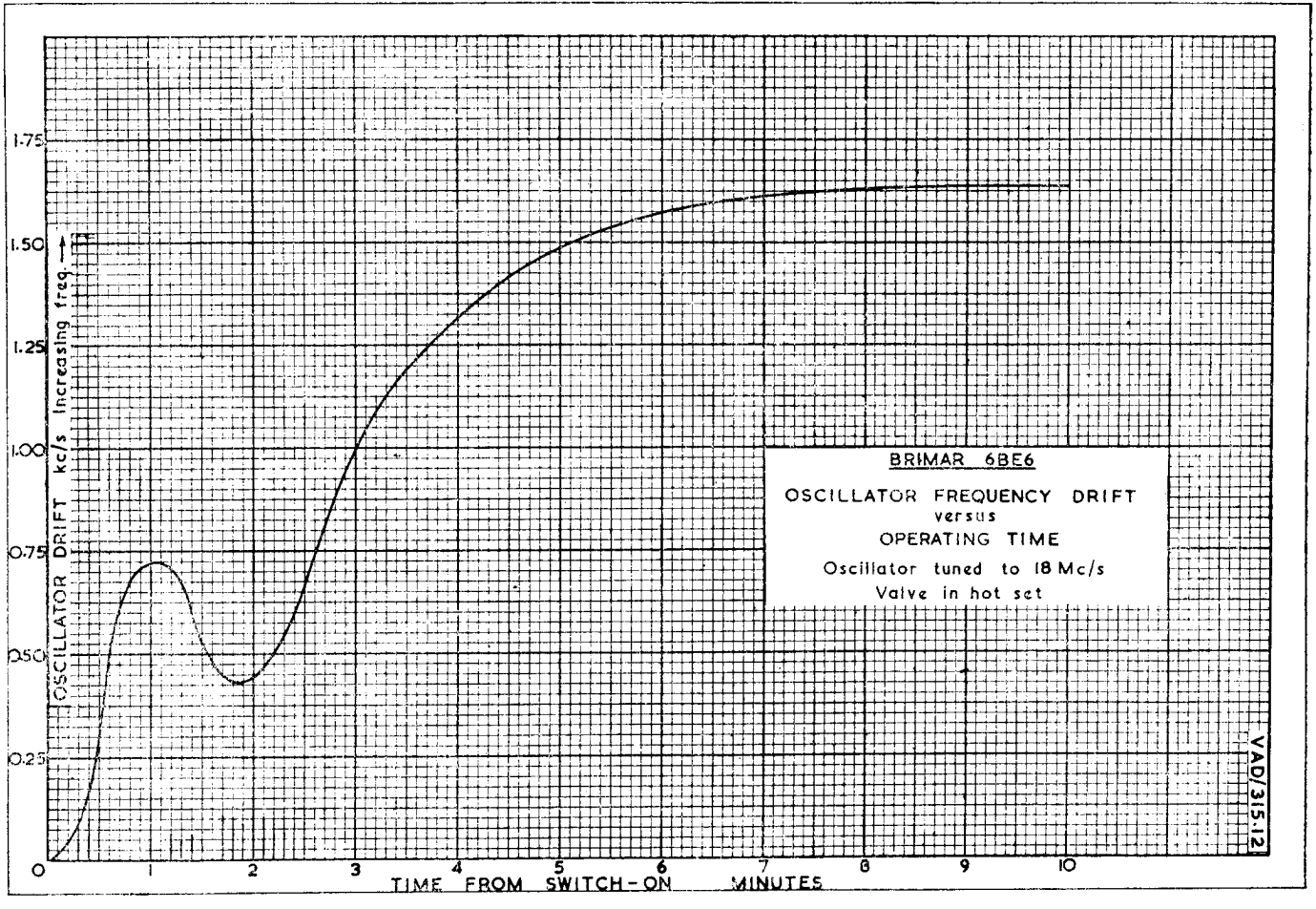
0
0.2
0.4
0.6
0.8
1.0
1.2

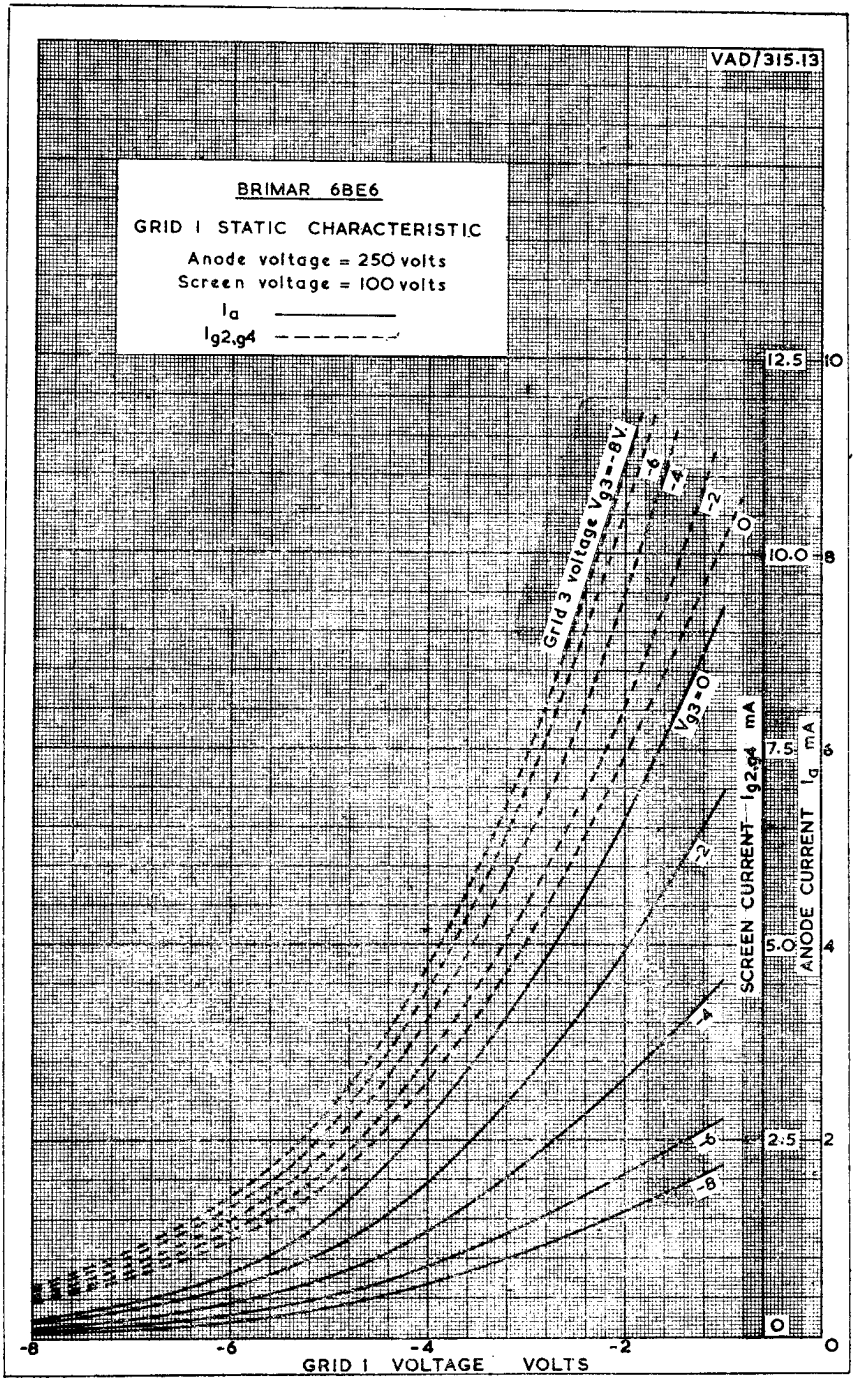
OSCILLATOR GRID CURRENT mA

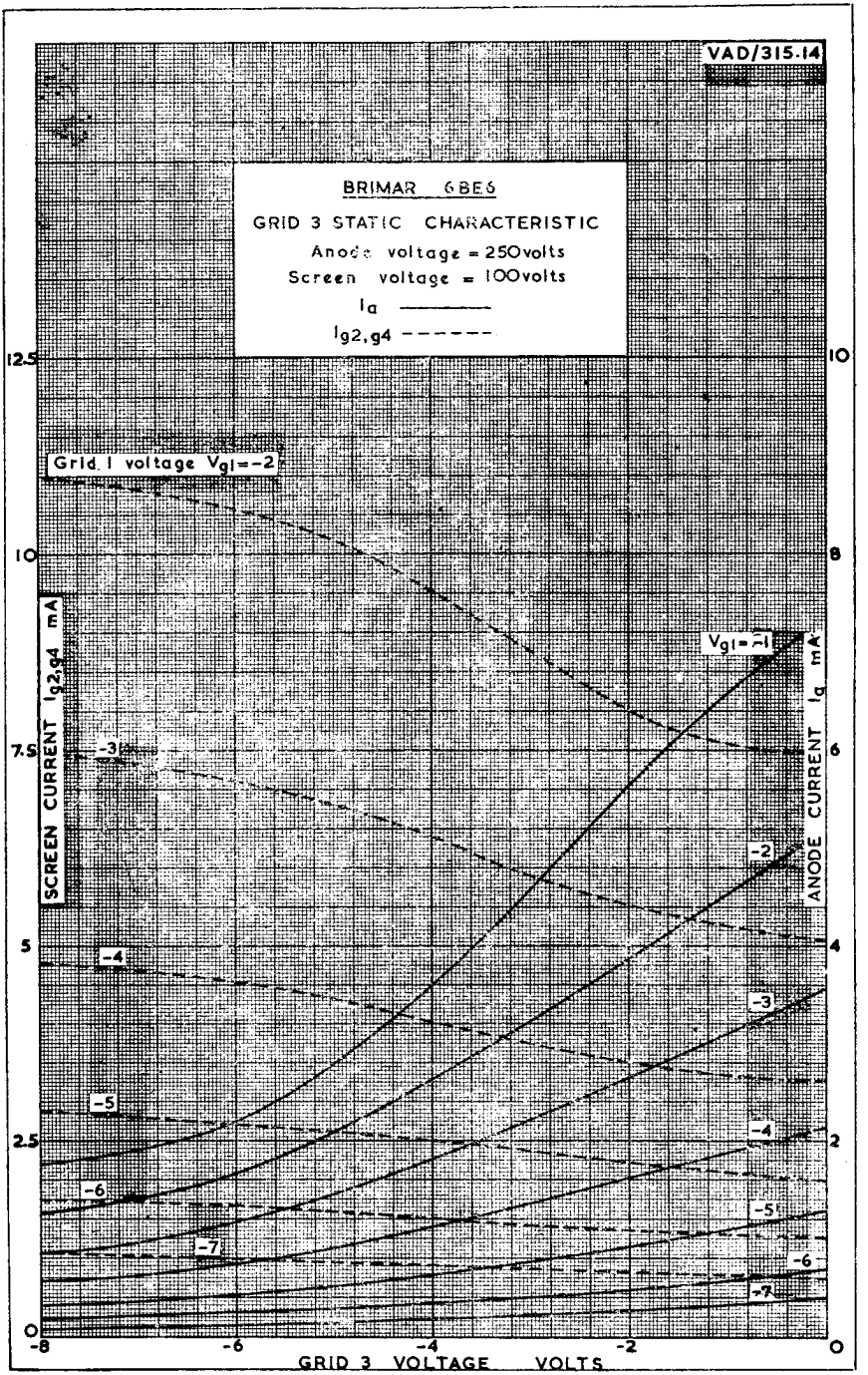

BRIMAR 6BE6
INPUT RESISTANCE & CAPACITY
versus
CONTROL GRID VOLTAGE
Frequency = 18 Mc/s
Anode voltage = 250 volts
Screen voltage = 100 volts
Oscillator grid current = 500 µA
Oscillator grid resistor = 22 kΩ
CONTROL GRID INPUT CAPACITY C_{in} pF
INPUT RESISTANCE r_{in} kΩ
9.0
8.5
8.0
200
100
0
r_{in}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

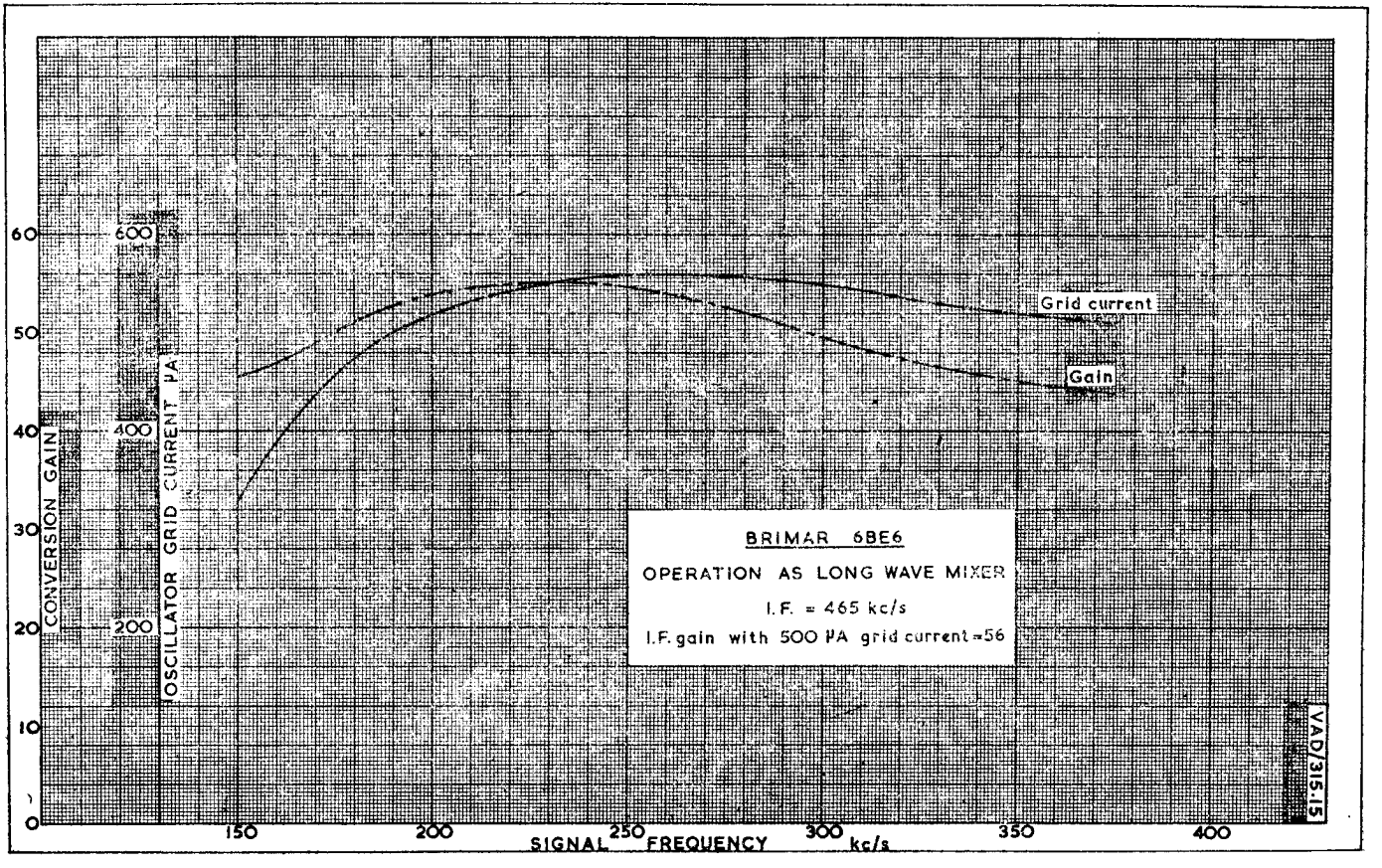

BRIMAR 6BE6
OSCILLATOR FREQUENCY DRIFT
versus
A.V.C. VOLTAGE
Oscillator tuned to 18Mc/s
OSCILLATOR FREQUENCY DRIFT kc/s
+3
+2
+1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
A.V.C. VOLTAGE VOLTS
VAD/315-10

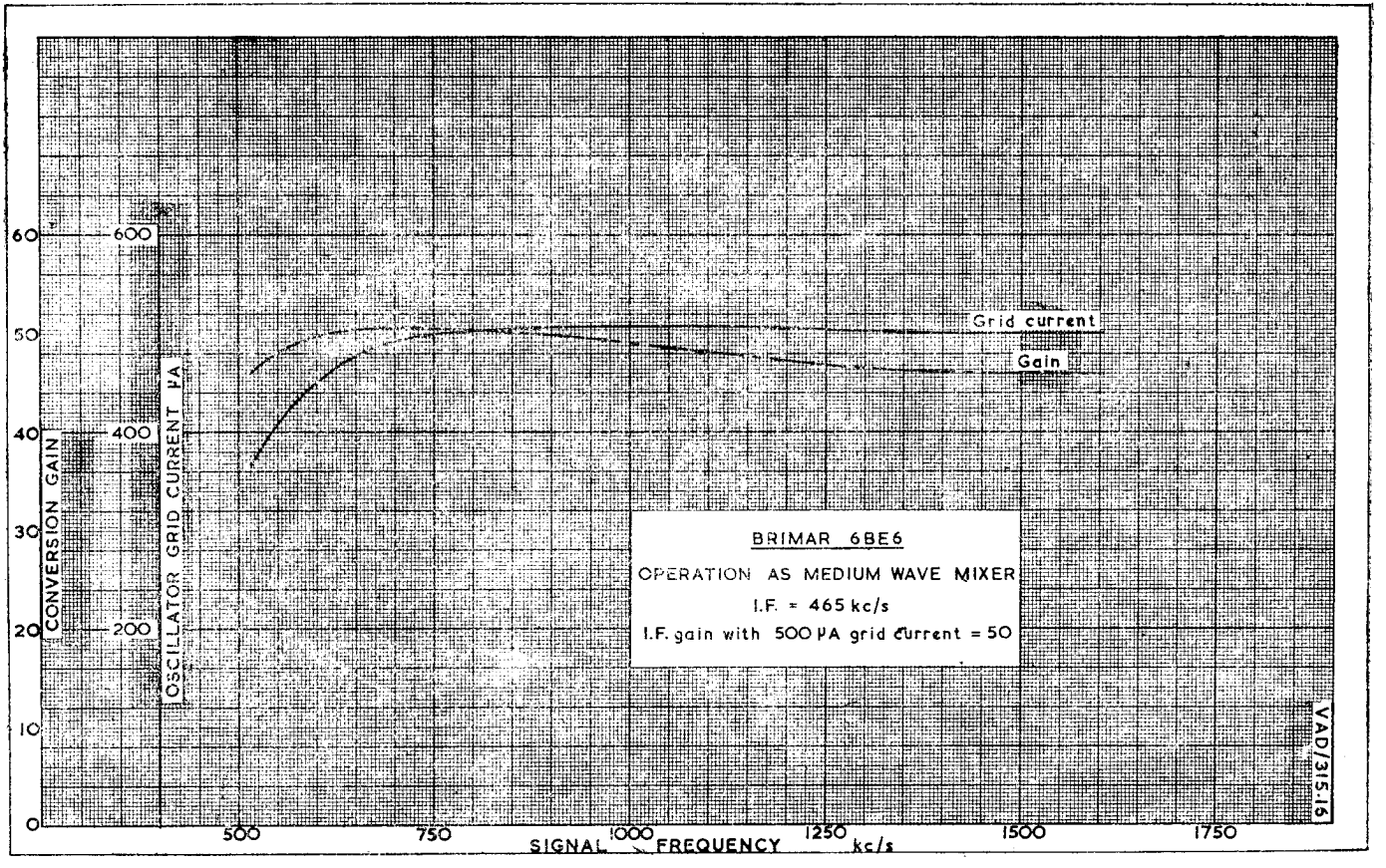

BRIMAR 6BE6
OSCILLATOR FREQUENCY DRIFT
versus
MAINS SUPPLY VOLTAGE
Oscillator tuned to 18 Mc/s
OSCILLATOR FREQUENCY DRIFT kc/s
+0.6
+0.4
+0.2
0
-0.2
-0.4
-0.6
205
210
220
230
240
250
255
MAINS SUPPLY VOLTAGE VOLTS
VAD/315.11

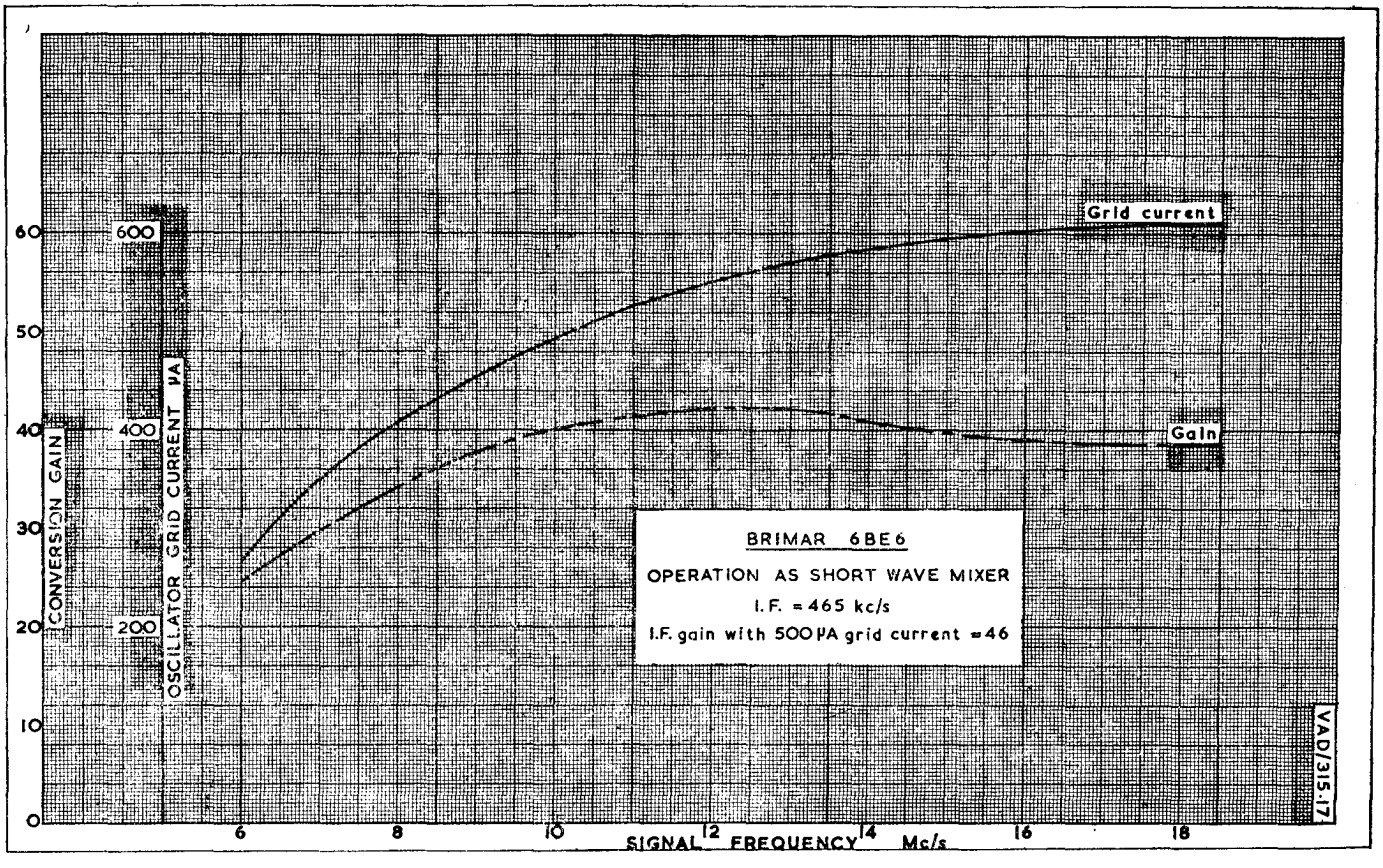

BRIMAR 6BE6
OSCILLATOR FREQUENCY DRIFT
versus
OPERATING TIME
Oscillator tuned to 18 Mc/s
Valve in hot set
OSCILLATOR DRIFT kc/s Increasing freq. →
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0
1
2
3
4
5
6
7
8
9
10
TIME FROM SWITCH-ON MINUTES
VAD/315.12


VAD/315.13
BRIMAR 6BE6
GRID I STATIC CHARACTERISTIC
Anode voltage = 250 volts
Screen voltage = 100 volts
I_a
$I_{g2,g4}$
Grid 3 voltage V_{g3} = -8V
-6
-4
-2
0
V_{g3} = 0
-2
-4
-6
-8
12.5
10.0
7.5
5.0
2.5
0
SCREEN CURRENT — $I_{g2,g4}$ mA
ANODE CURRENT I_a mA
10
8
6
4
2
0
-8
-6
-4
-2
0
GRID 1 VOLTAGE VOLTS

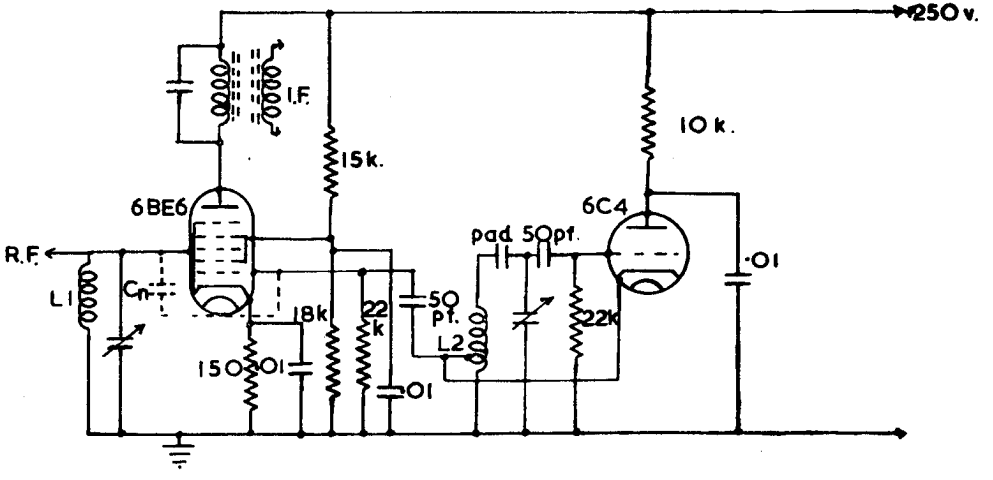

VAD/315.14
BRIMAR 6BE6
GRID 3 STATIC CHARACTERISTIC
Anode voltage = 250volts
Screen voltage = 100volts
Ia ———
Ig2,g4 - - - - - -
Grid 1 voltage Vg1=-2
Vg1=-1
-3
-4
-5
-6
-7
SCREEN CURRENT Ig2,g4 mA
ANODE CURRENT Ia mA
GRID 3 VOLTAGE VOLTS
12.5
10
7.5
5
2.5
0
-8
-6
-4
-2
0
8
6
4
2


CONVERSION GAIN
OSCILLATOR GRID CURRENT µA
60
50
40
30
20
10
0
600
400
200
Grid current
Gain
BRIMAR 6BE6
OPERATION AS LONG WAVE MIXER
I.F. = 465 kc/s
I.F. gain with 500 µA grid current = 56
150
200
250
300
350
400
SIGNAL FREQUENCY kc/s
VA/D/3515


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


CONVERSION GAIN
OSCILLATOR GRID CURRENT μA
600
400
200
60
50
40
30
20
10
0
6
8
10
12
14
16
18
SIGNAL FREQUENCY Mc/s
Grid current
Gain
BRIMAR 6BE6
OPERATION AS SHORT WAVE MIXER
I.F. = 465 kc/s
I.F. gain with 500μA grid current = 46
VAD/315-7

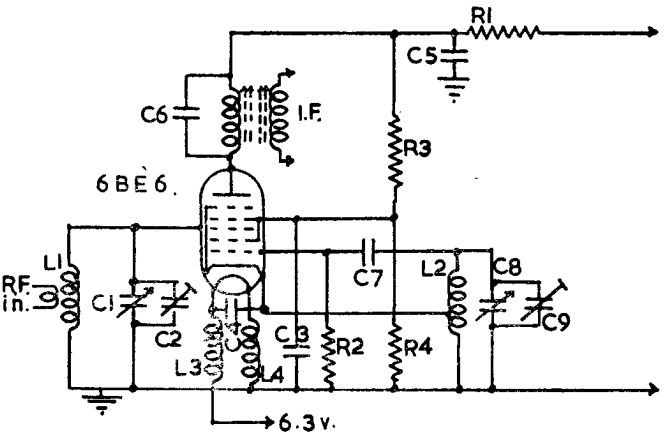
BRIMAR 6BE6 CONVERTER, SEPARATELY EXCITED BY 6C4 OSCILLATOR



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

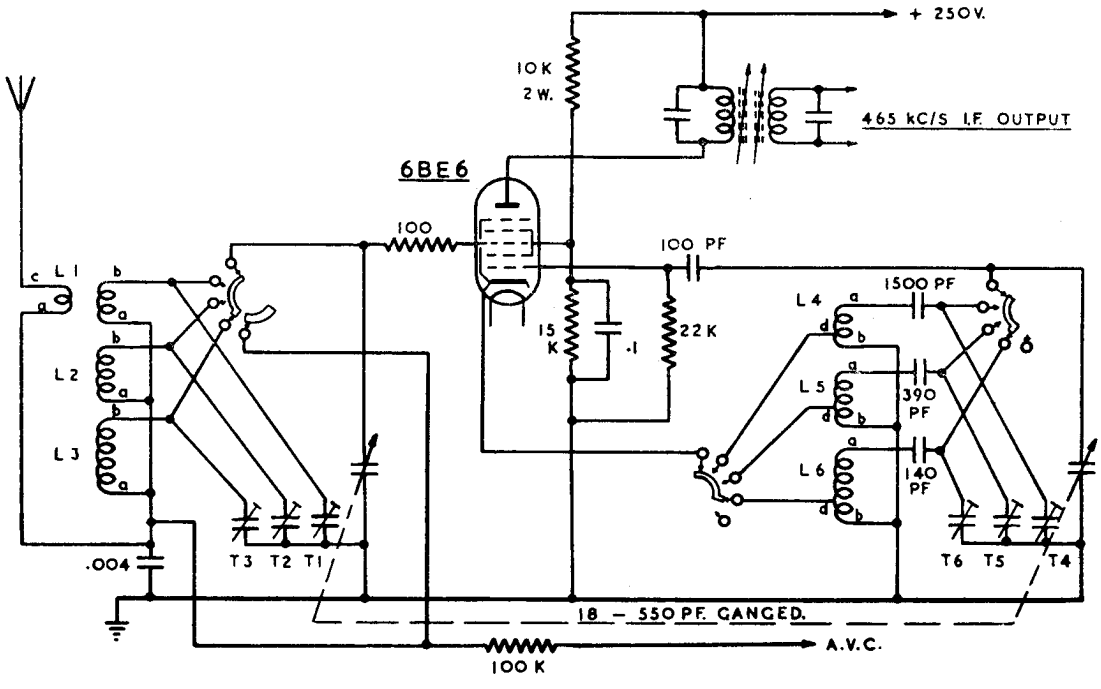
VAD/315.53

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.

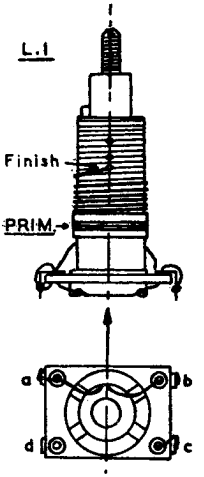
BRIMAR 6BE6 LONG, MEDIUM & SHORT WAVE CONVERTER CIRCUIT



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".

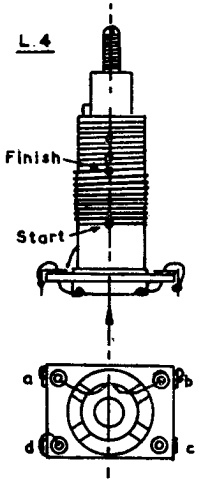
Finish taken through hole in former to tag "b".

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".

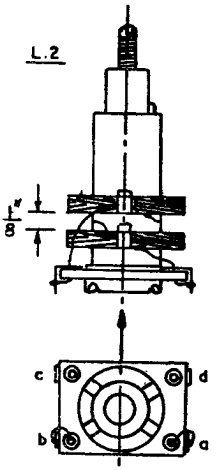
Finish taken through hole in former to tag "a".

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 = 193·5 μH
Q at 1 Mc/s = 160

M.W. AERIAL

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

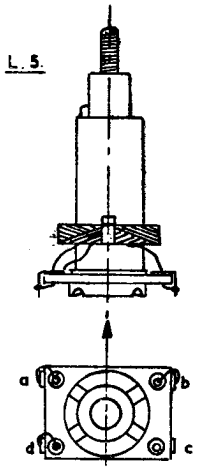
Iron Dust Core: Neosid Z.11.B.

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 = 120·5 μH
Q at 1 Mc/s = 44

M.W. OSCILLATOR

Former: As for L.2.

Iron Dust Core: As for L.2.

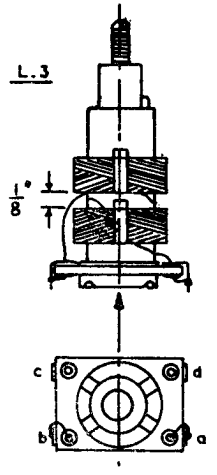
Winding: 70 turns of 38 D.S.C. Cu. tapped at 6 turns.

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

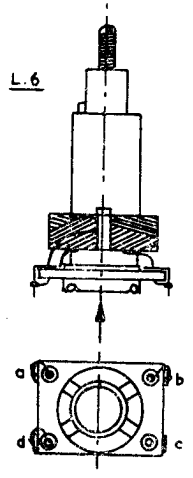
Former: 1/2″ outside diameter, moulded bakelite.

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.

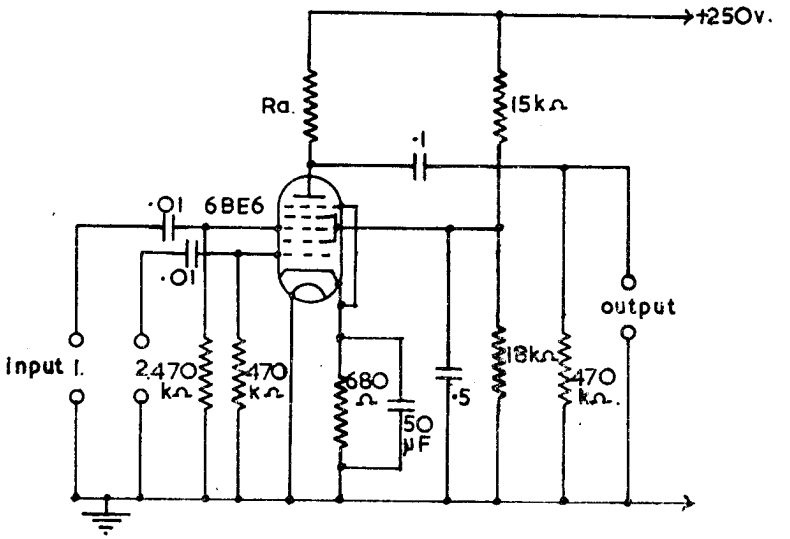
Iron Dust Core: Diameter 10 mm. Length 17 mm. with 4BA brass screw insert 1″ long.

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.RMS.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 g1	
	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 g2	
	Pin 9 Suppressor Grid g3	

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 $\frac{\mu R_a}{R_a + r_a} = \frac{17 \times 180}{207 \cdot 2}$ 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 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.

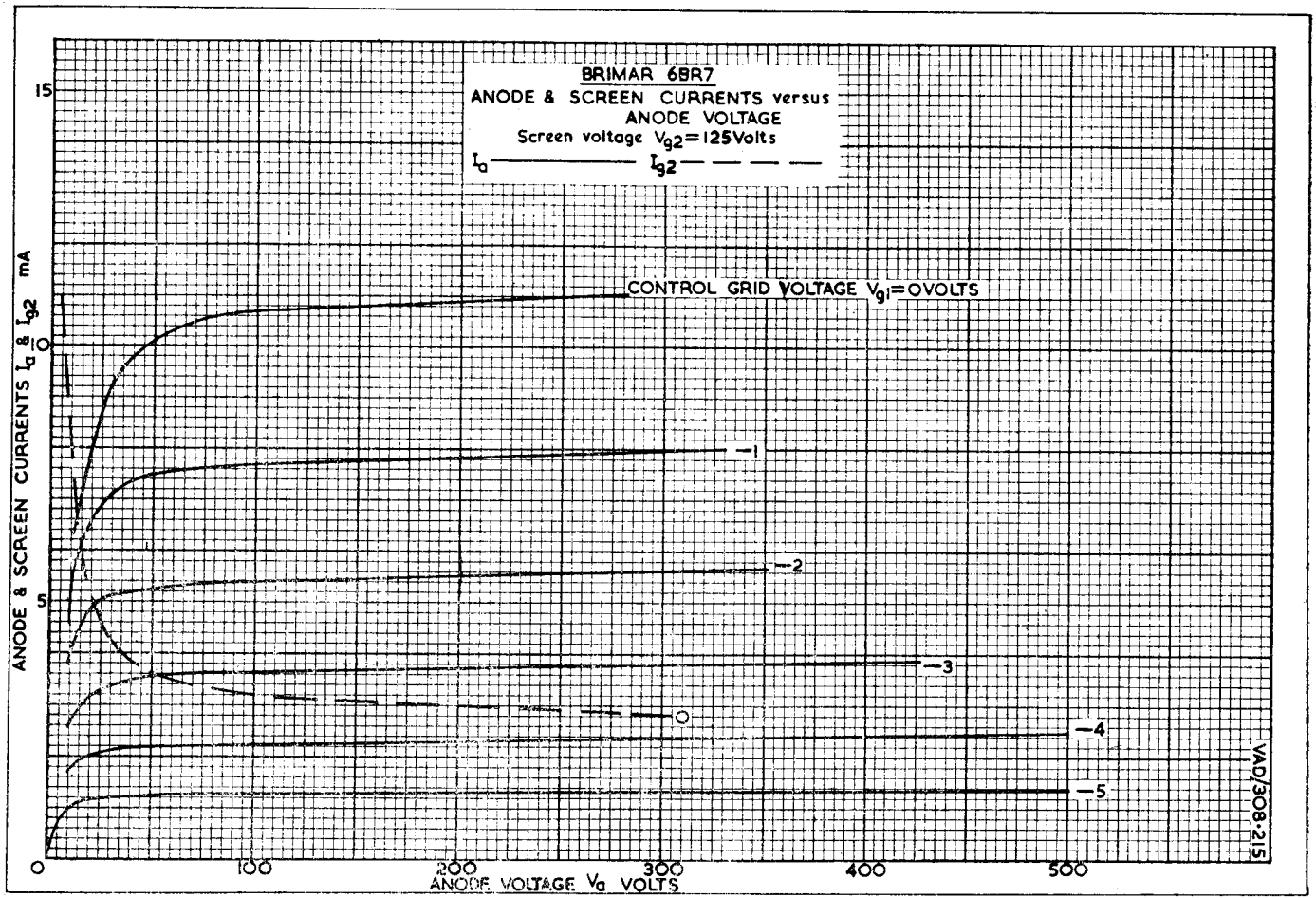
The shot noise in the 6BR7 has been reduced to a minimum by careful design, and the noise due to leakage controlled by careful assembly and inspection. A certain amount of leakage noise is unavoidable in a mass produced valve, and this reveals itself as a small variation in noise level from valve to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

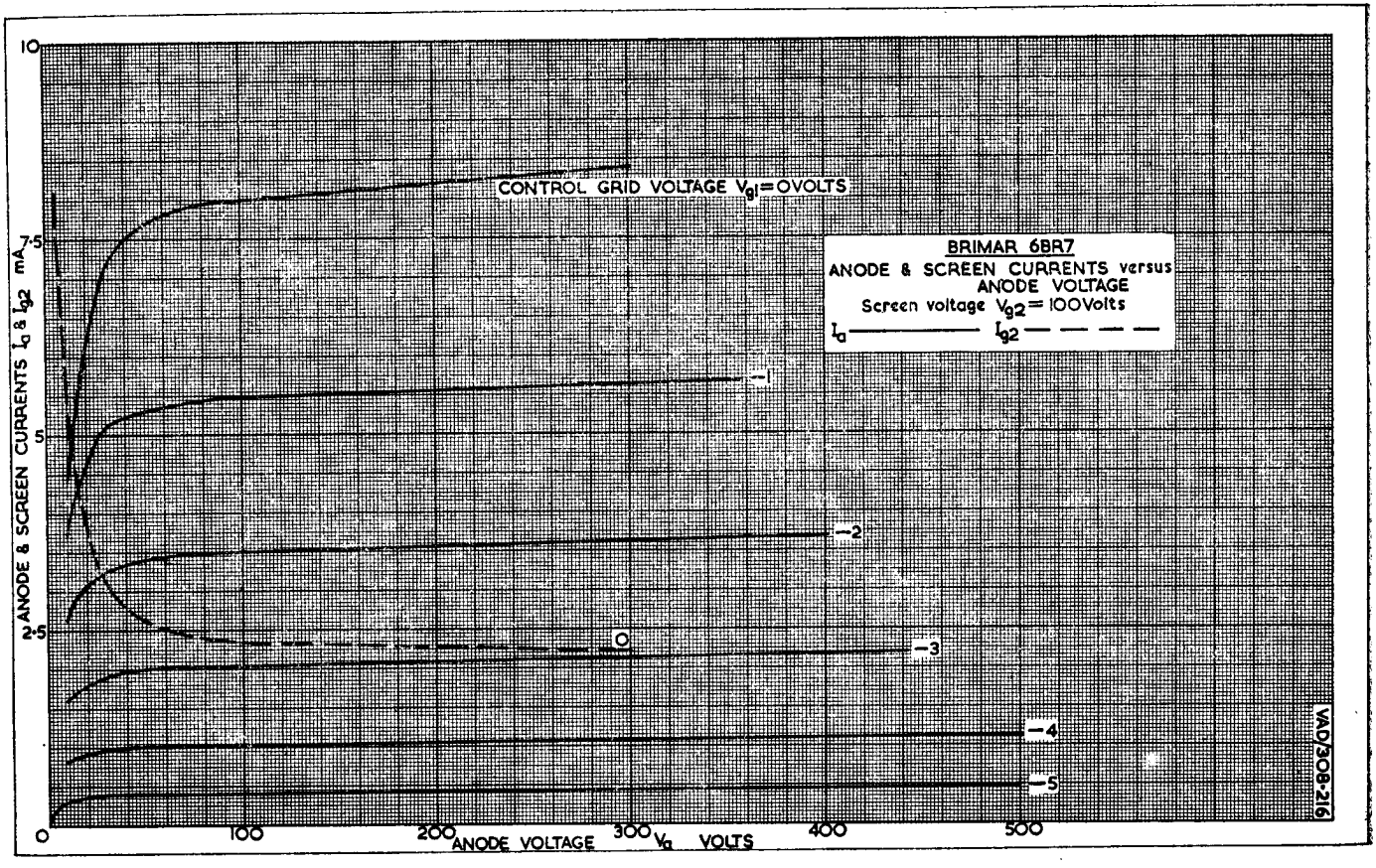
The curve No. 308·228 shows the maximum hiss voltage plotted against the percentage of valves, using a grid resistor of 100 kΩ and a bandwidth of 10 kc/s. The curve is very steep and indicates that a hiss level on the grid always lower than 7μV is to be expected.

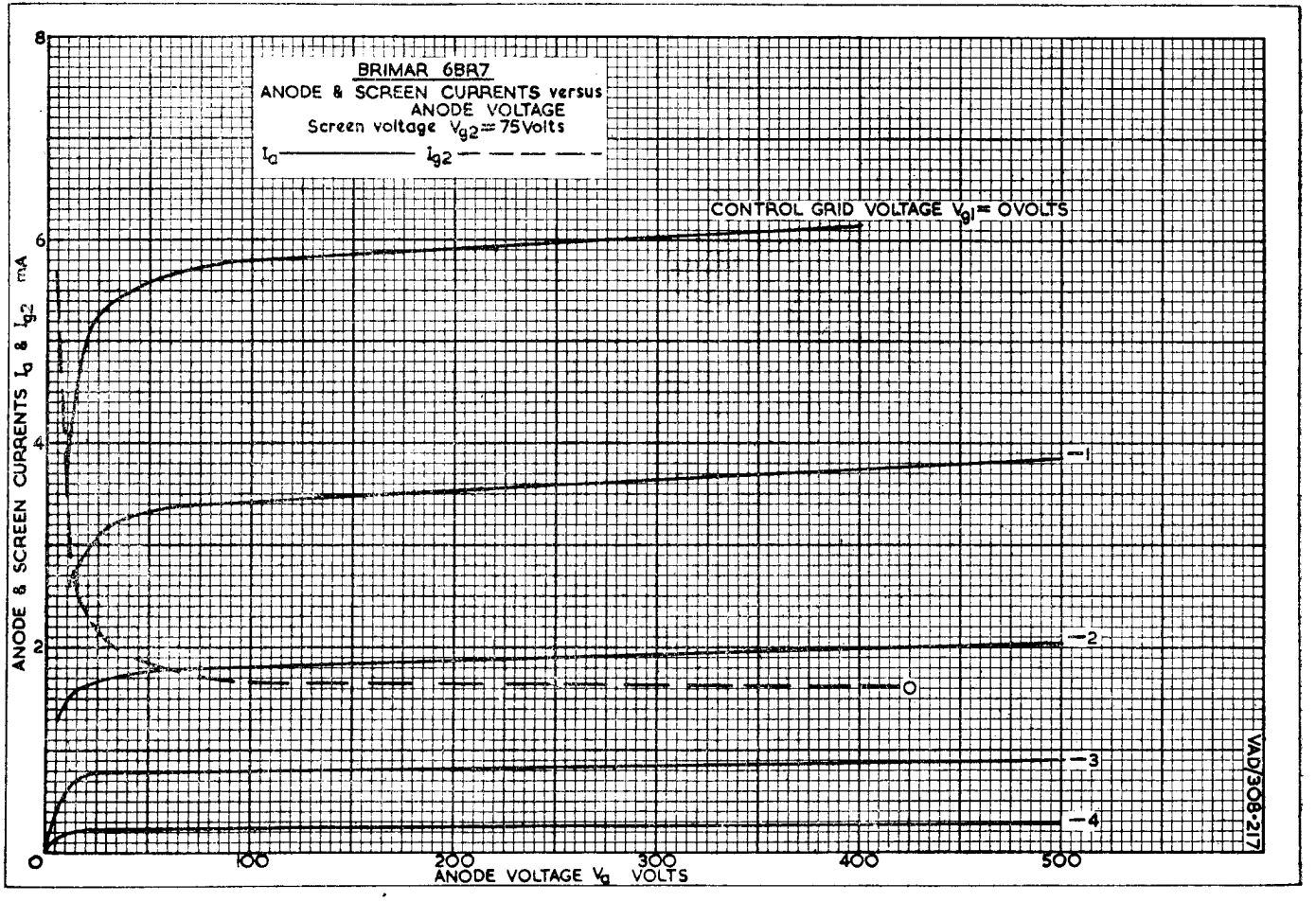
The Curve No. 308·230 shows the same parameters with the valve triode connected. Here partition noise has been eliminated. As would be expected the higher noise levels are unaltered because they are due mainly to leakage which is not greatly affected by whether the valve is triode or pentode connected. 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.

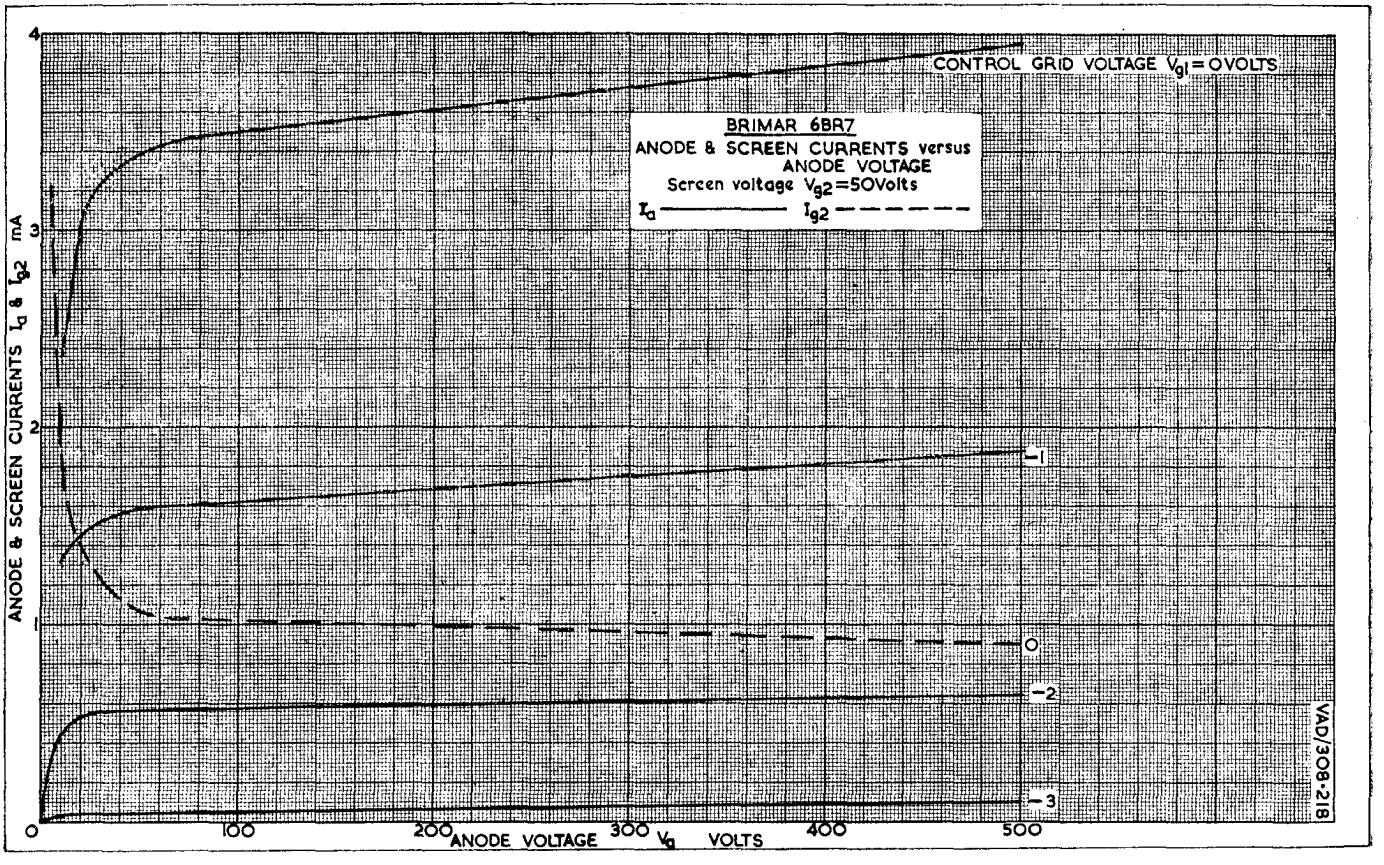
9.0 Conclusions: While it is not claimed that the 6BR7 has exceptionally low noise properties, it can be stated that it is a very great improvement over average normal valves. Individual samples taken at random from a large batch can be expected to give consistently good performance. As with normal receiving 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.

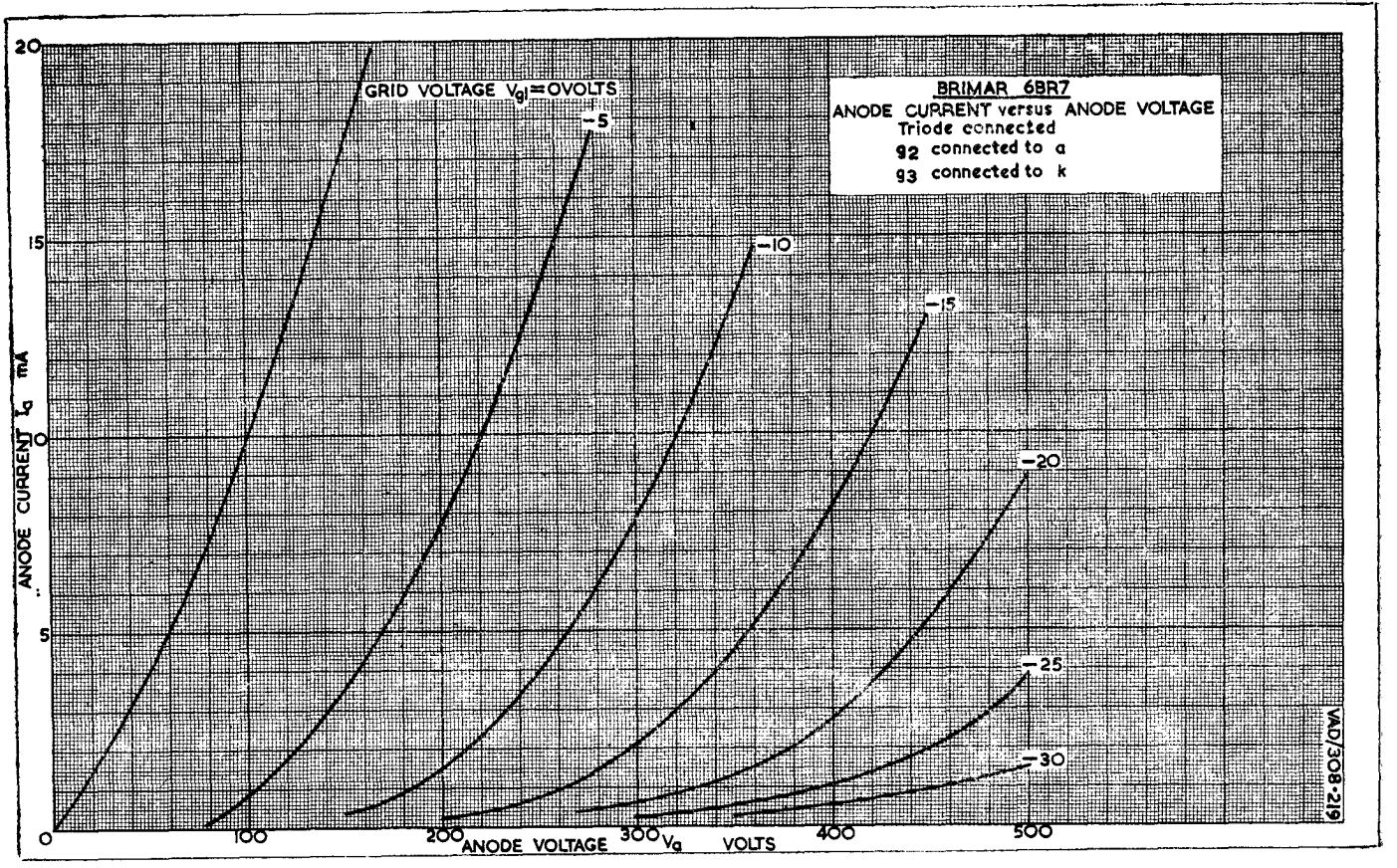
In spite of this, care must be taken when designing prototype equipment for high gain, low noise applications, to ensure that the design is not finalised from the experience acquired from a single sample of the 6BR7.

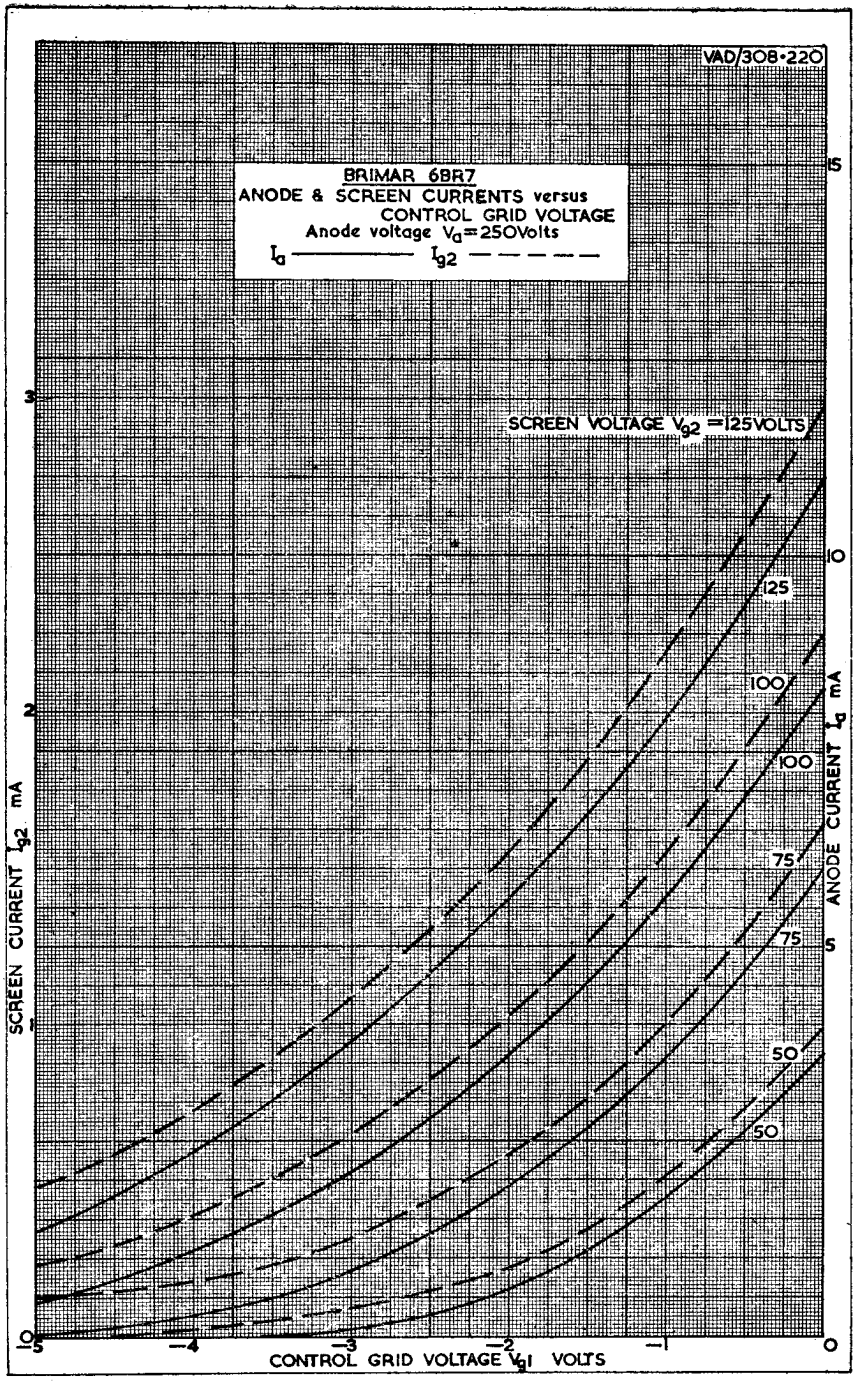

BRIMAR 6BR7
ANODE & SCREEN CURRENTS versus ANODE VOLTAGE
Screen voltage V_{g2}=125Volts
I_a —— I_{g2} — — — —
CONTROL GRID VOLTAGE V_{g1}=0VOLTS
-1
-2
-3
-4
-5
0
ANODE & SCREEN CURRENTS I_a & I_{g2} mA
15
10
5
0
100
200
300
400
500
ANODE VOLTAGE V_a VOLTS
VAD/308-215

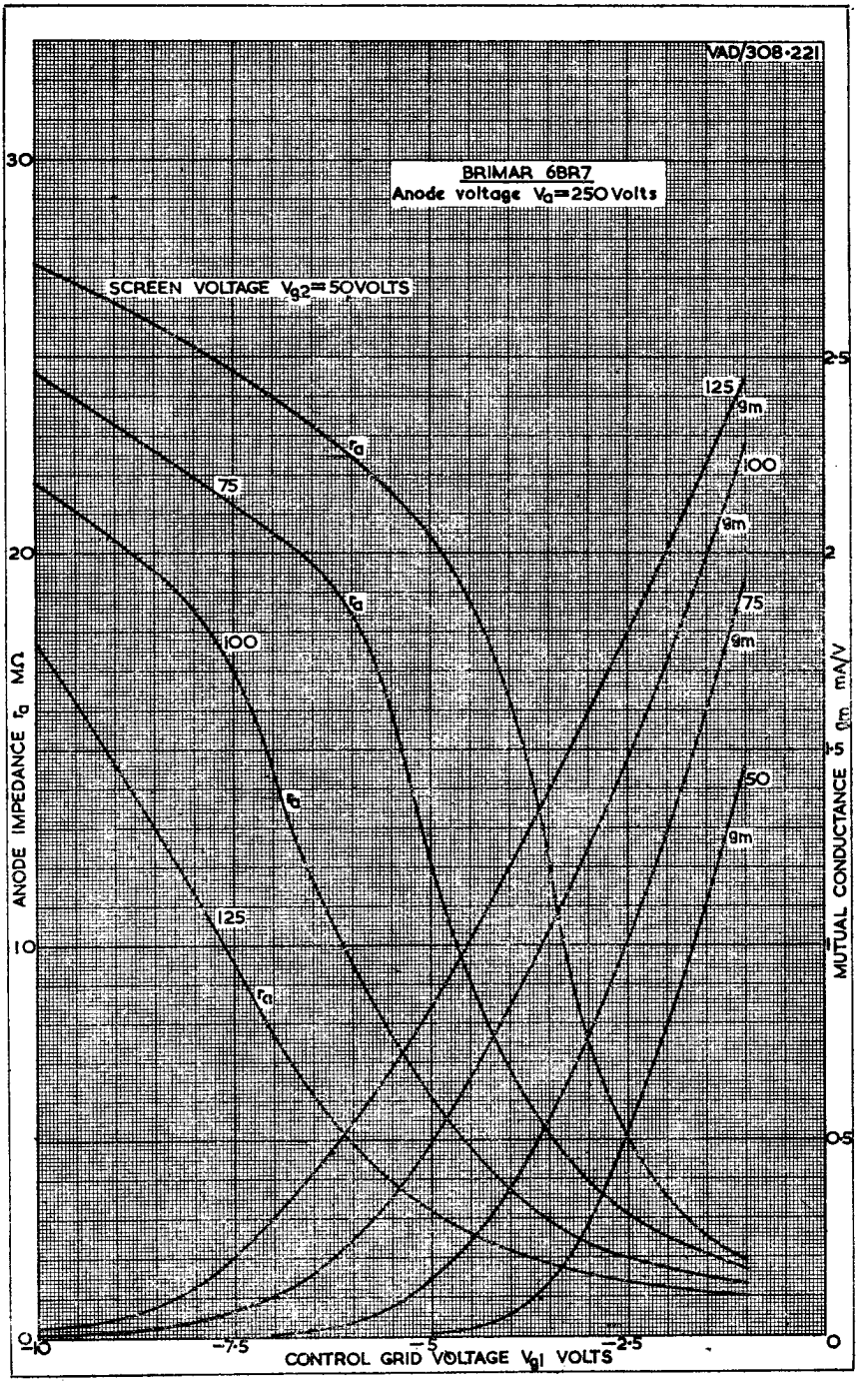

BRIMAR 6BR7
ANODE & SCREEN CURRENTS versus ANODE VOLTAGE
Screen voltage V_{g2} = 100 Volts
I_a ——— I_{g2} — — — —
CONTROL GRID VOLTAGE V_{g1} = 0 VOLTS
-1
-2
0
-3
-4
-5
ANODE & SCREEN CURRENTS I_a & I_{g2} mA
10
7·5
5
2·5
0
100
200
300
400
500
ANODE VOLTAGE V_a VOLTS
VAD/308-216

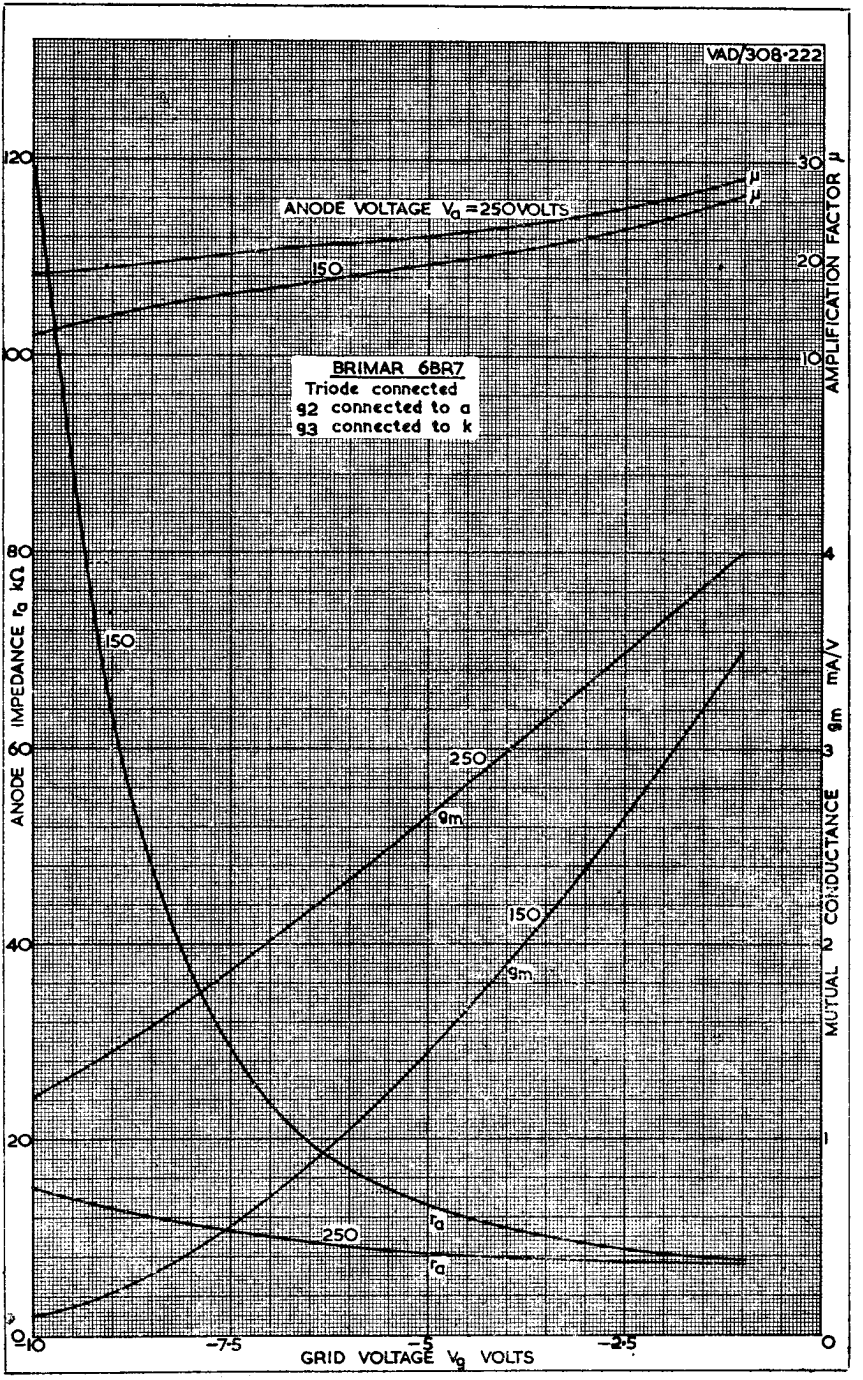

BRIMAR 6BR7
ANODE & SCREEN CURRENTS versus ANODE VOLTAGE
Screen voltage V_{g2} = 75 Volts
I_a —— I_{g2} - - - -
CONTROL GRID VOLTAGE V_{g1} = 0 VOLTS
ANODE & SCREEN CURRENTS I_a & I_{g2} mA
ANODE VOLTAGE V_a VOLTS
0
2
4
6
8
100
200
300
400
500
-1
-2
0
-3
-4
VAD/308-217

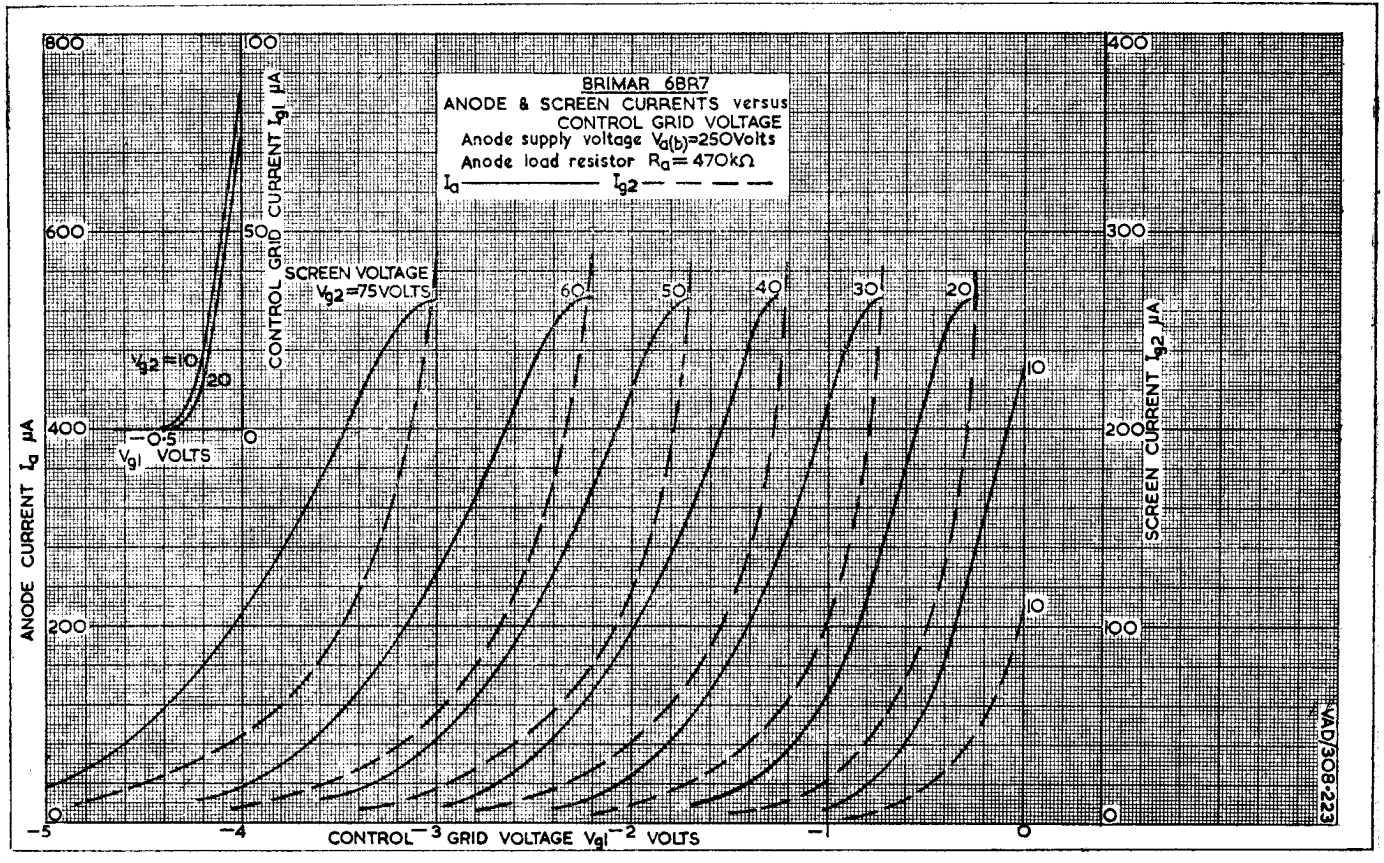

BRIMAR 6BR7
ANODE & SCREEN CURRENTS versus ANODE VOLTAGE
Screen voltage V_{g2}=50Volts
I_a ——— I_{g2} - - - - -
CONTROL GRID VOLTAGE V_{g1}=0VOLTS
-1
0
-2
-3
ANODE & SCREEN CURRENTS I_a & I_{g2} mA
ANODE VOLTAGE V_a VOLTS
0
100
200
300
400
500
1
2
3
4
VAD/308-218

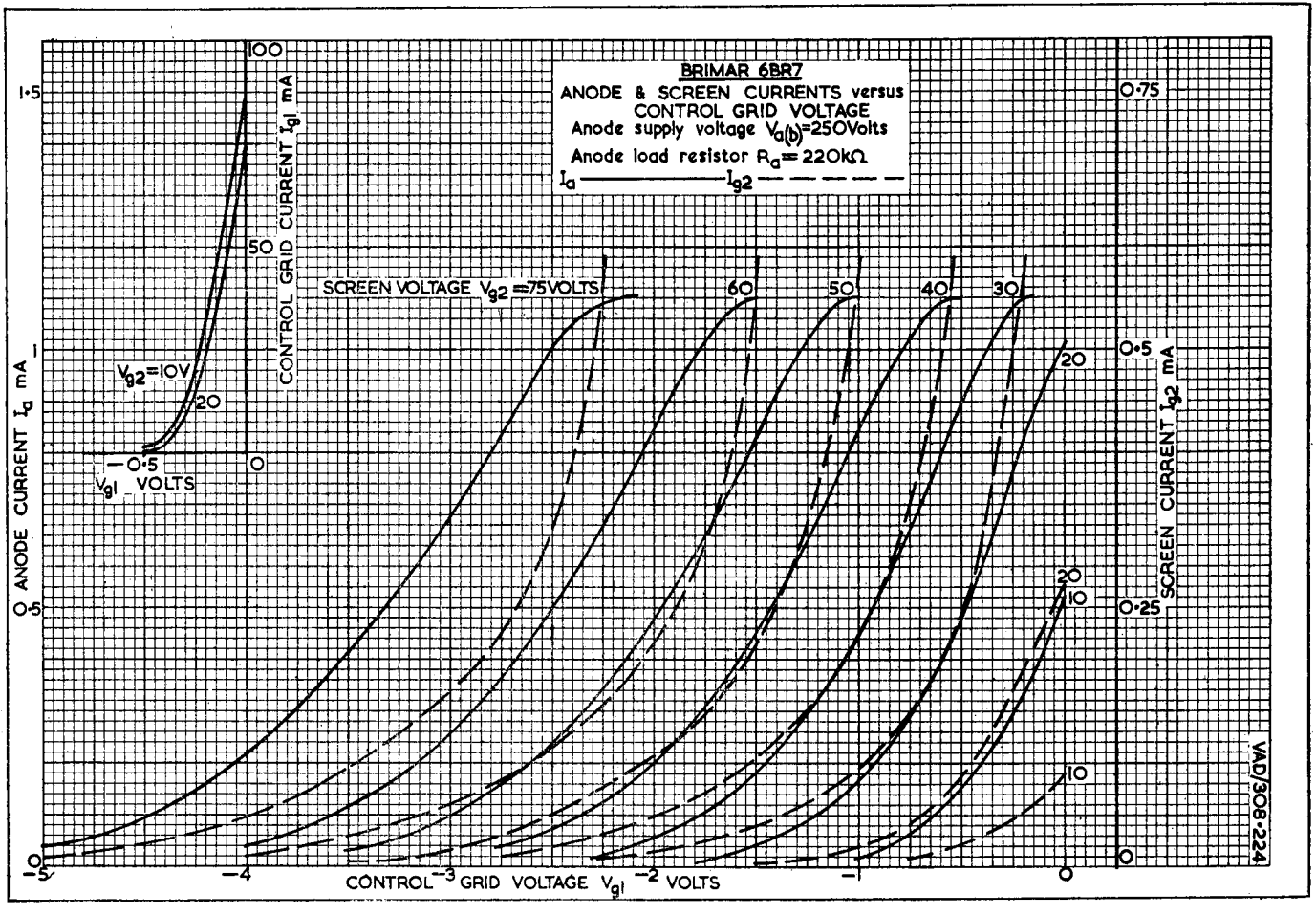

BRIMAR 6BR7
ANODE CURRENT versus ANODE VOLTAGE
Triode connected
g2 connected to a
g3 connected to k
GRID VOLTAGE V_{g1} = 0 VOLTS
-5
-10
-15
-20
-25
-30
ANODE CURRENT I_a mA
ANODE VOLTAGE V_a VOLTS
0
5
15
20
100
200
300
400
500
VAD/308-219

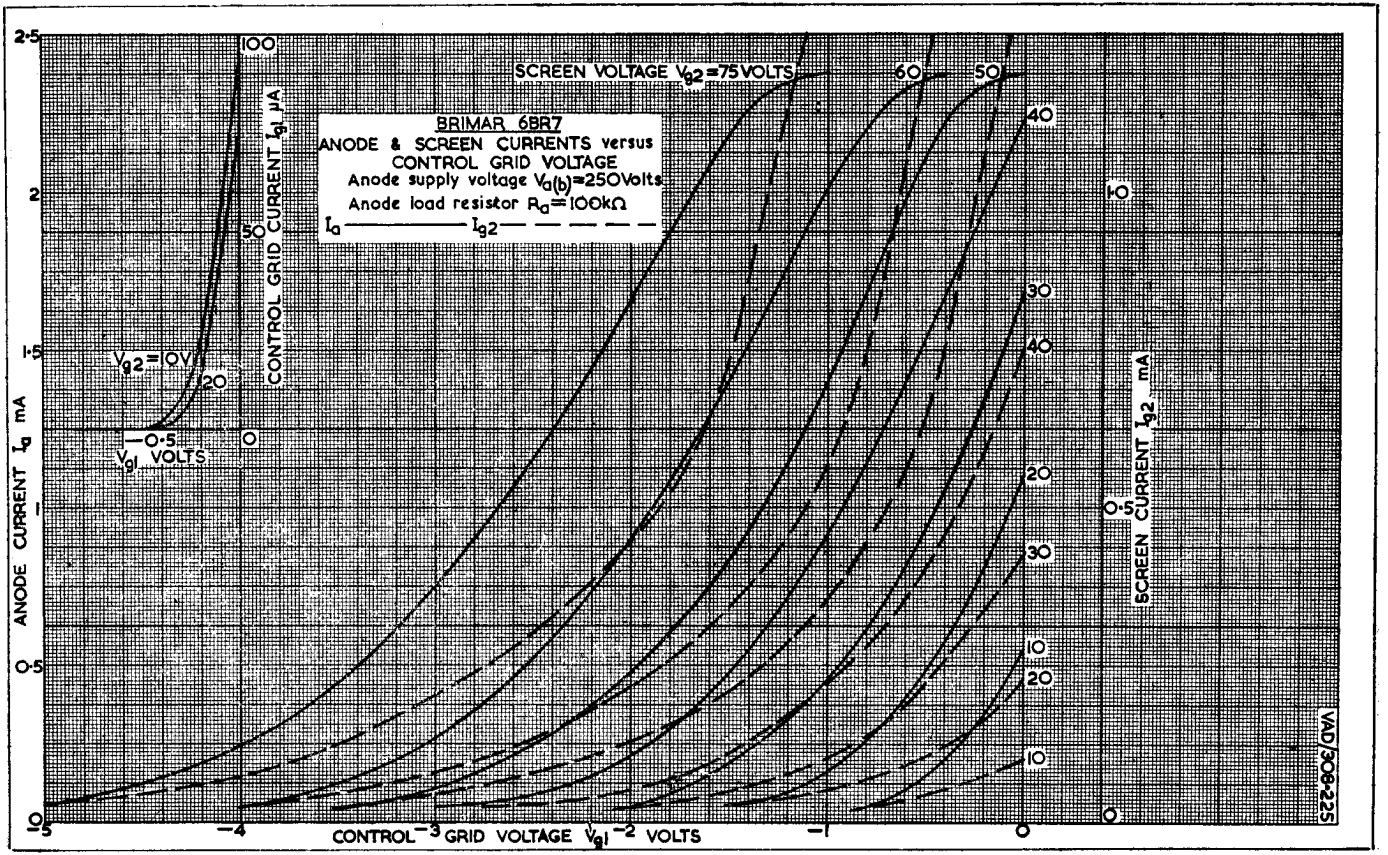

VAD/308·220
BRIMAR 6BR7
ANODE & SCREEN CURRENTS versus
CONTROL GRID VOLTAGE
Anode voltage V_a=250Volts
I_a ——— I_{g2} — — — —
SCREEN VOLTAGE V_{g2} =125VOLTS
125
100
100
75
75
50
50
SCREEN CURRENT I_{g2} mA
ANODE CURRENT I_a mA
CONTROL GRID VOLTAGE V_{g1} VOLTS
0
−1
−2
−3
−4
−5
5
10
15
2
3

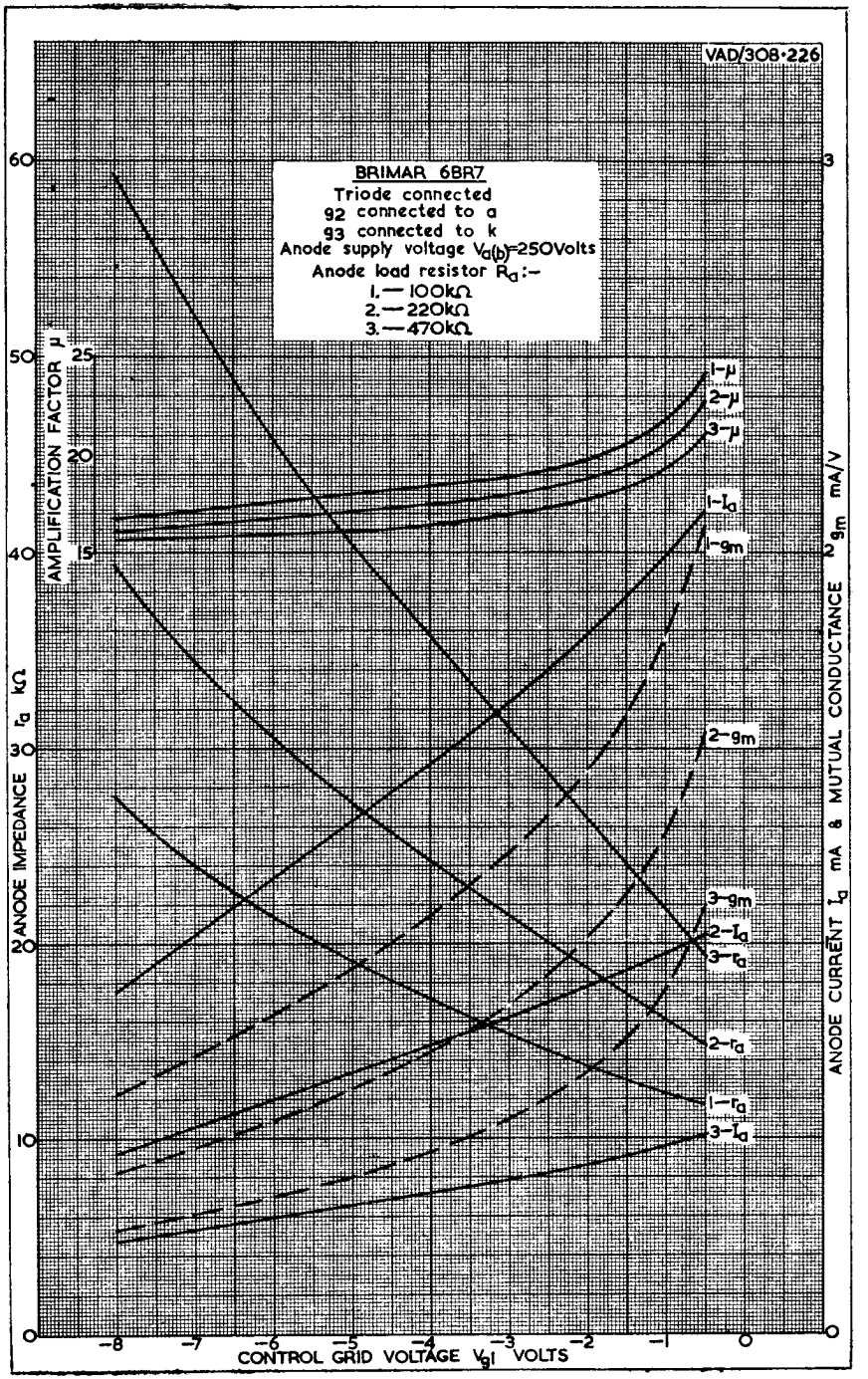

VAD/308·221
BRIMAR 6BR7
Anode voltage V_a=250 Volts
SCREEN VOLTAGE V_{g2}=50VOLTS
125
r_a
75
r_a
100
r_a
125
r_a
125
9m
100
9m
75
9m
50
9m
30
20
10
0
2·5
2
1·5
0·5
0
−10
−7·5
−5
−2·5
ANODE IMPEDANCE r_a MΩ
MUTUAL CONDUCTANCE 9m mA/V
CONTROL GRID VOLTAGE V_{g1} VOLTS

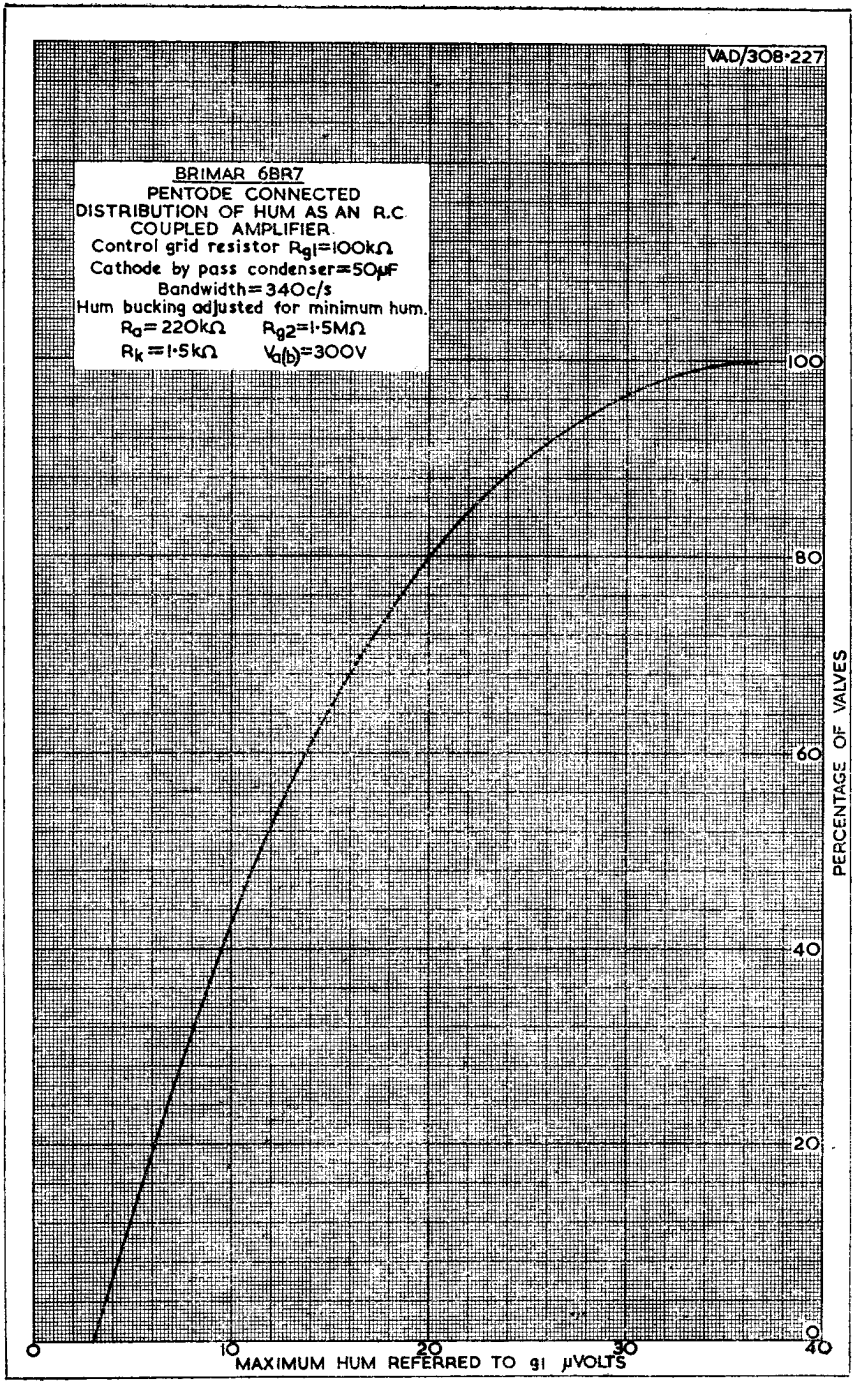

VAD/308·222
ANODE VOLTAGE V_a = 250 VOLTS
μ
μ
150
BRIMAR 6BR7
Triode connected
g2 connected to a
g3 connected to k
150
250
g_m
150
g_m
r_a
250
r_a
ANODE IMPEDANCE r_a kΩ
MUTUAL CONDUCTANCE g_m mA/V
AMPLIFICATION FACTOR μ
GRID VOLTAGE V_g VOLTS
120
100
80
60
40
20
0
30
20
10
4
3
2
1
0
-10
-7·5
-5
-2·5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


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
−0·5
0
V_{g1} VOLTS
ANODE CURRENT I_a μA
CONTROL GRID CURRENT I_{g1} μA
SCREEN CURRENT I_{g2} μA
CONTROL GRID VOLTAGE V_{g1} VOLTS
800
600
400
200
0
100
50
0
400
300
200
100
0
−5
−4
−3
−2
−1
0
VAD308-223

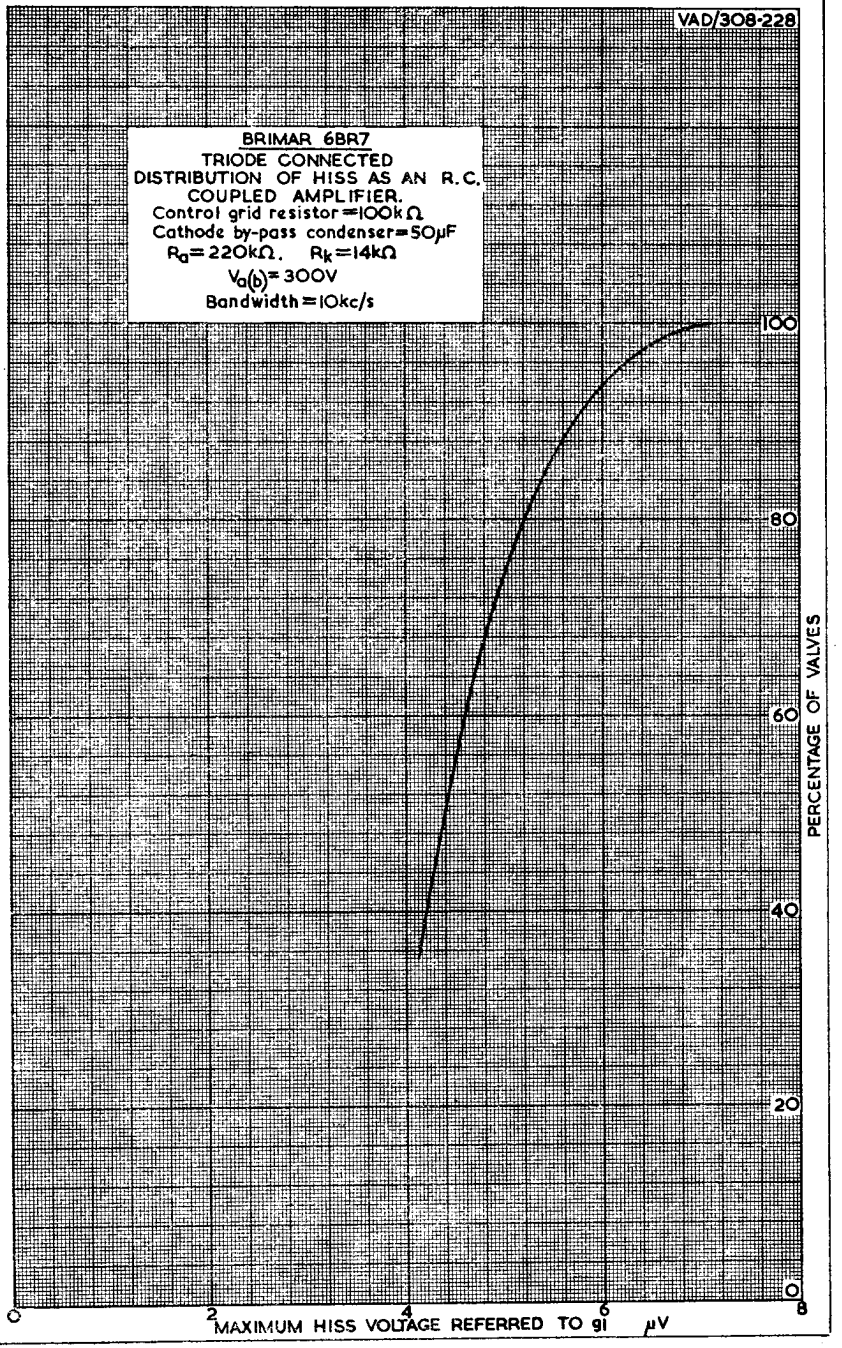

BRIMAR 6BR7
ANODE & SCREEN CURRENTS versus CONTROL GRID VOLTAGE
Anode supply voltage $V_{a(b)}$=250Volts
Anode load resistor R_a=220kΩ
I_a ——— I_{g2} — — — —
ANODE CURRENT I_a mA
SCREEN CURRENT I_{g2} mA
CONTROL GRID CURRENT I_{g1} mA
CONTROL GRID VOLTAGE V_{g1} VOLTS
SCREEN VOLTAGE V_{g2} =75VOLTS
V_{g2}=10V
VAD/308·224


BRIMAR 6BR7
ANODE & SCREEN CURRENTS versus
CONTROL GRID VOLTAGE
Anode supply voltage $V_{a(b)}$=250Volts
Anode load resistor R_a=100kΩ
I_a ——— I_{g2} — — — —
SCREEN VOLTAGE V_{g2}=75 VOLTS
60
50
40
30
20
10
V_{g2}=10V
120
100
50
0
−0·5
V_{g1} VOLTS
CONTROL GRID CURRENT I_{g1} μA
ANODE CURRENT I_a mA
SCREEN CURRENT I_{g2} mA
CONTROL GRID VOLTAGE V_{g1} VOLTS
2·5
2
1·5
1
0·5
0
−5
−4
−3
−2
−1
0
VAD/308-225

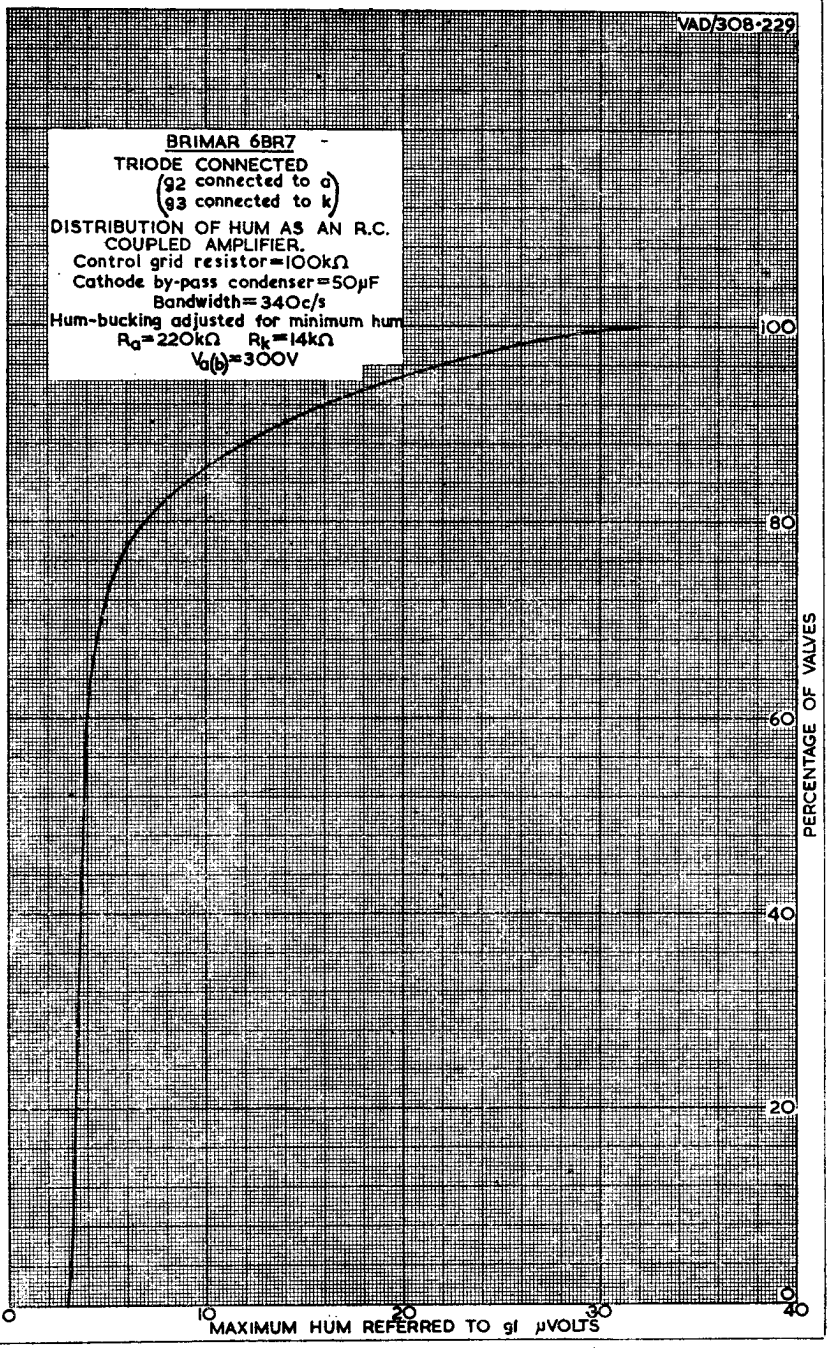

VAD/308·226
BRIMAR 6BR7
Triode connected
g2 connected to a
g3 connected to k
Anode supply voltage Va(b)=250Volts
Anode load resistor Ra :-
1.— 100kΩ
2.— 220kΩ
3.— 470kΩ
AMPLIFICATION FACTOR μ
ANODE IMPEDANCE ra kΩ
ANODE CURRENT Ia mA & MUTUAL CONDUCTANCE gm mA/V
CONTROL GRID VOLTAGE Vg1 VOLTS
1-μ
2-μ
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 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
10
20
30
40
MAXIMUM HUM REFERRED TO g1 μVOLTS

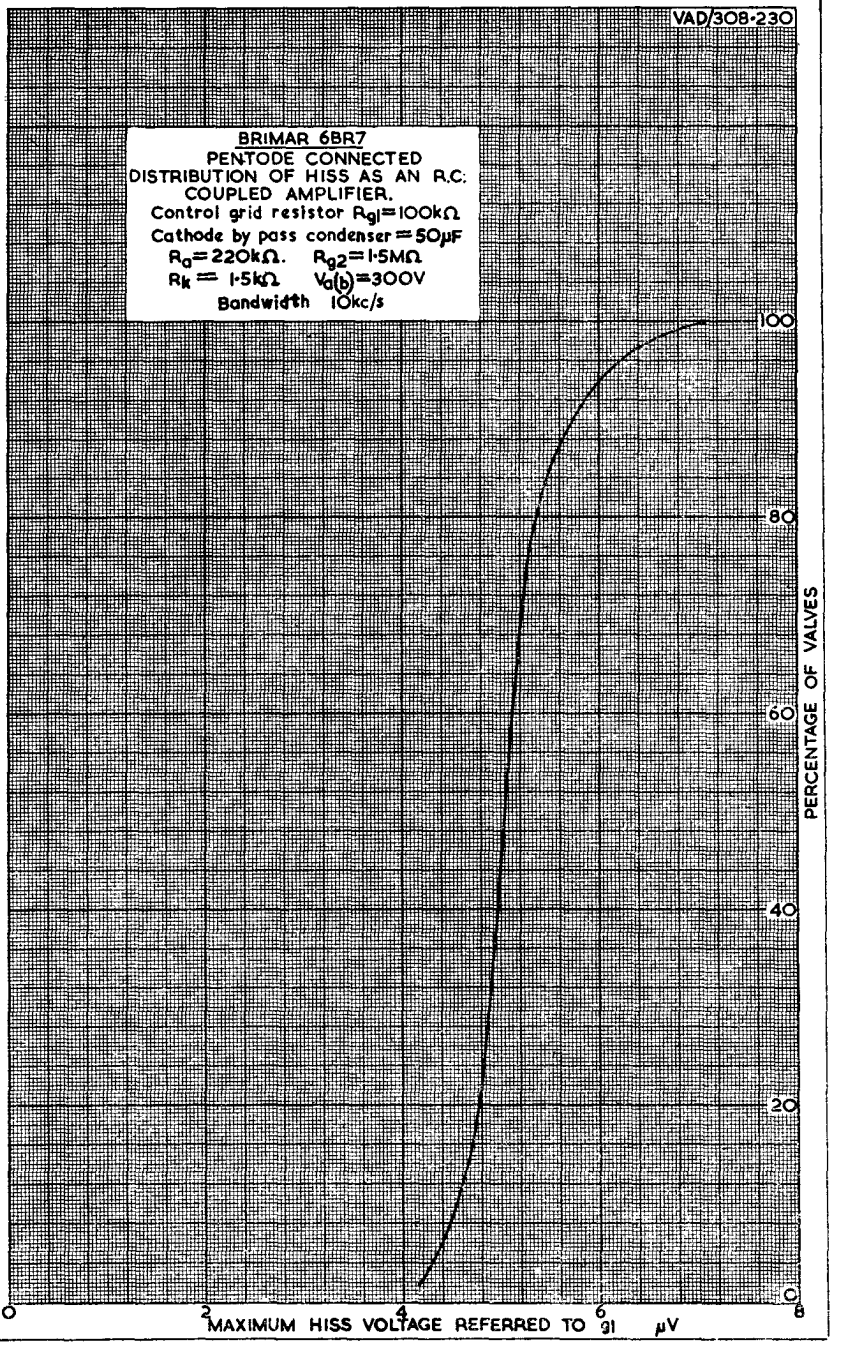
BRIMAR 6BR7
TRIODE CONNECTED
DISTRIBUTION OF HISS AS AN R.C. COUPLED AMPLIFIER.
Control grid resistor = 100kΩ
Cathode by-pass condenser = 50μF
R_a = 220kΩ. R_k = 1·4kΩ
$V_{a(b)}$ = 300V
Bandwidth = 10kc/s



VAD/308-229

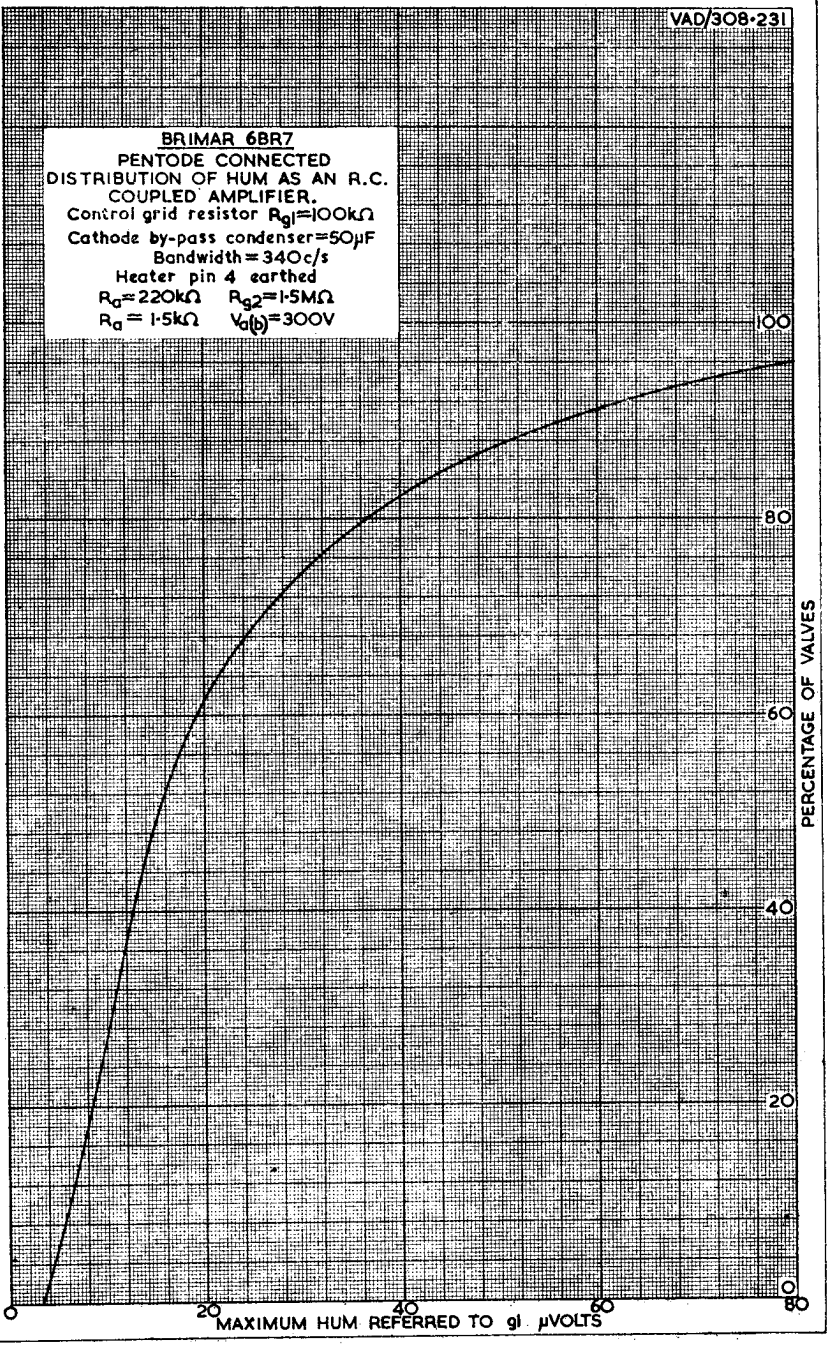

BRIMAR 6BR7
TRIODE CONNECTED
(g2 connected to a
g3 connected to k)
DISTRIBUTION OF HUM AS AN R.C. COUPLED AMPLIFIER.
Control grid resistor=100kΩ
Cathode by-pass condenser=50μF
Bandwidth=340c/s
Hum-bucking adjusted for minimum hum
R_a=220kΩ R_k=1.4kΩ
$V_{a(b)}$=300V
100
80
60
40
20
0
0
10
20
30
40
PERCENTAGE OF VALVES
MAXIMUM HUM REFERRED TO g1 μVOLTS

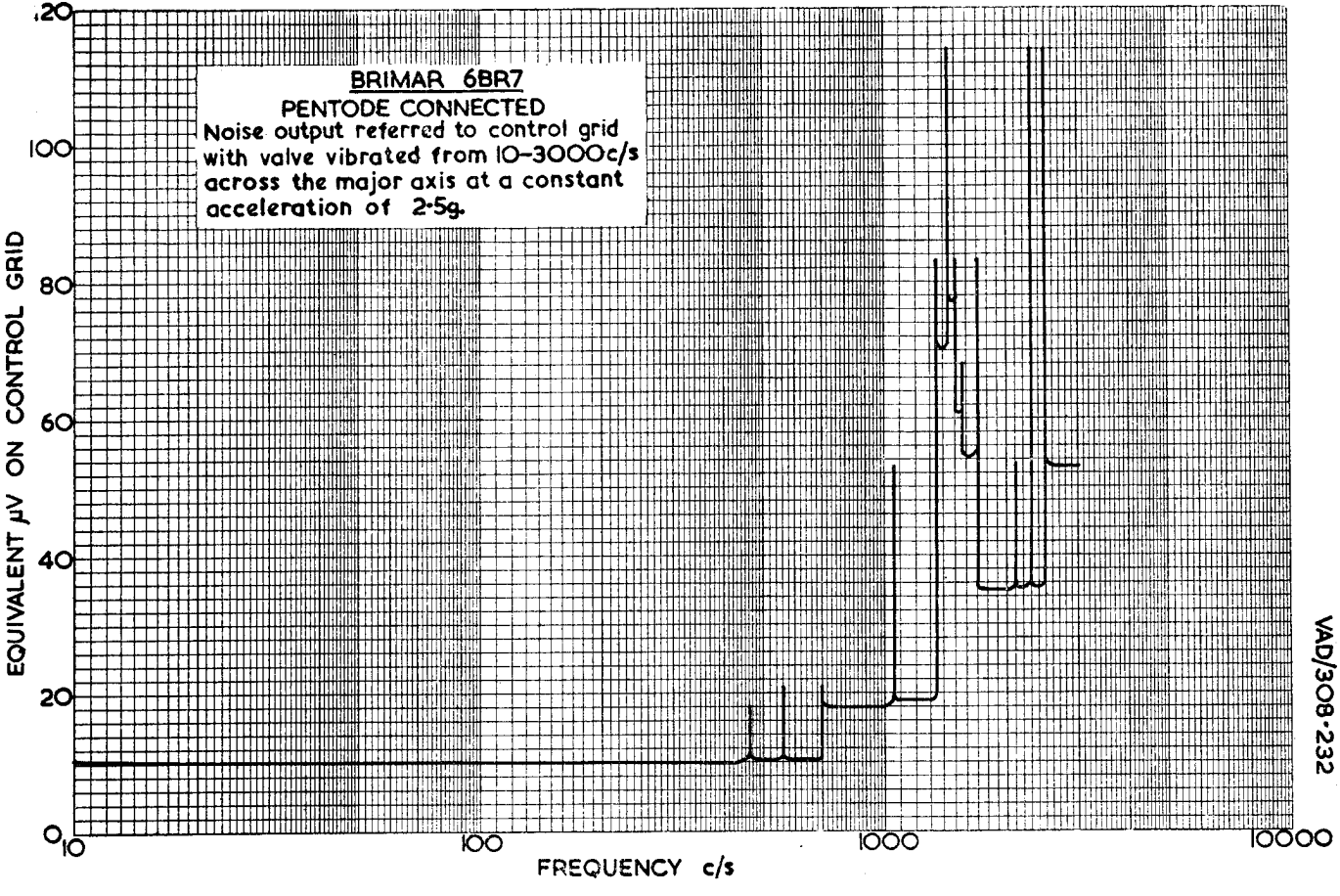
BRIMAR 6BR7
PENTODE CONNECTED
DISTRIBUTION OF HISS AS AN R.C. COUPLED AMPLIFIER.
Control grid resistor R_{g1}=100kΩ
Cathode by pass condenser=50μF
R_a=220kΩ. R_{g2}=1·5MΩ
R_k=1·5kΩ $V_{a(b)}$=300V
Bandwidth 10kc/s

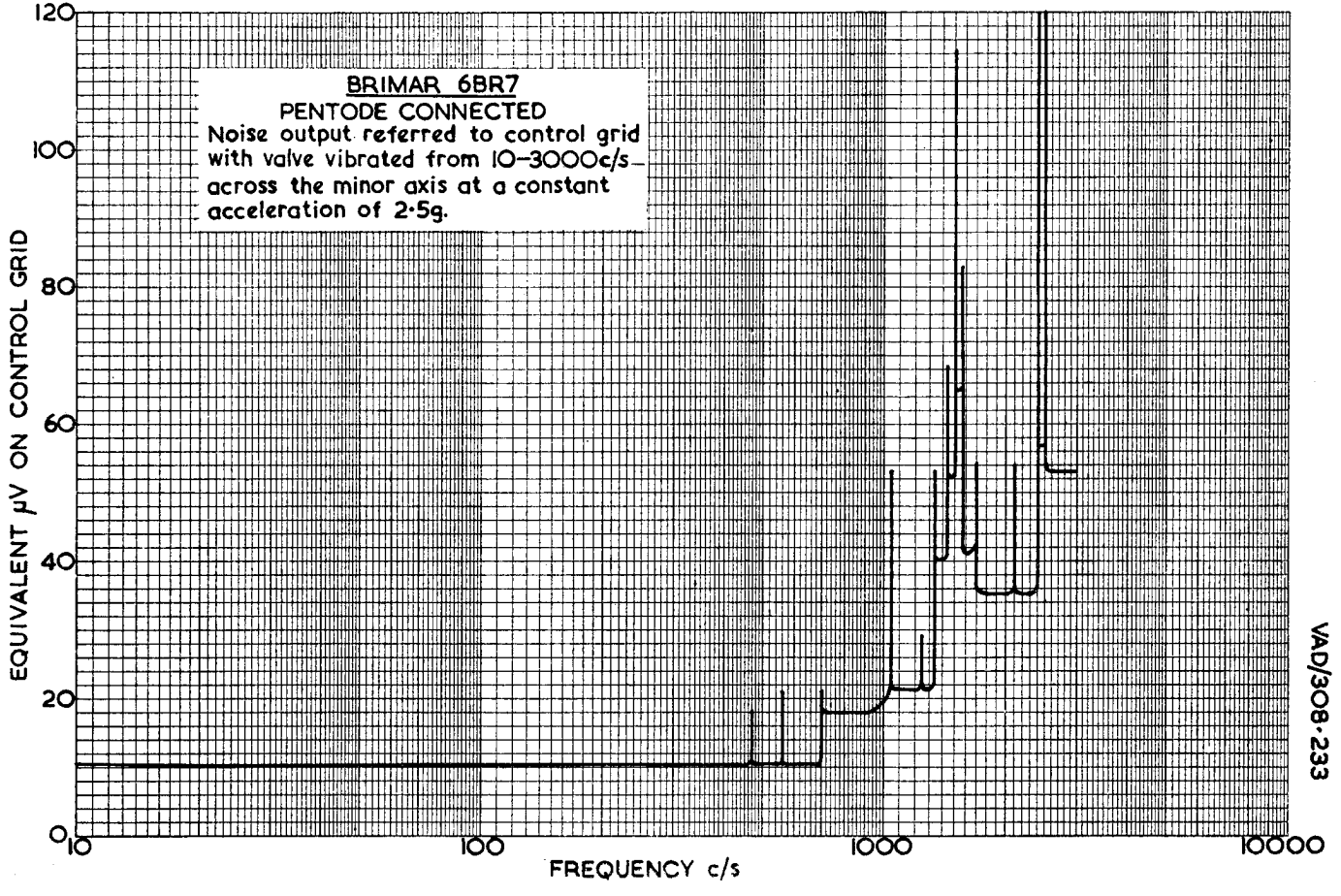


VAD/308·231

BRIMAR 6BR7
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
Heater pin 4 earthed
R_a=220kΩ R_{g2}=1·5MΩ
R_a=1·5kΩ $V_{a(b)}$=300V




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
120
100
80
60
40
20
0
10
100
1000
10000
FREQUENCY c/s
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
120
100
80
60
40
20
0
10
100
1000
10000
FREQUENCY c/s
VAD/308·233

BRIMAR

RECEIVING VALVE

6BS7

APPLICATION REPORT VAD/508.4

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Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

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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.

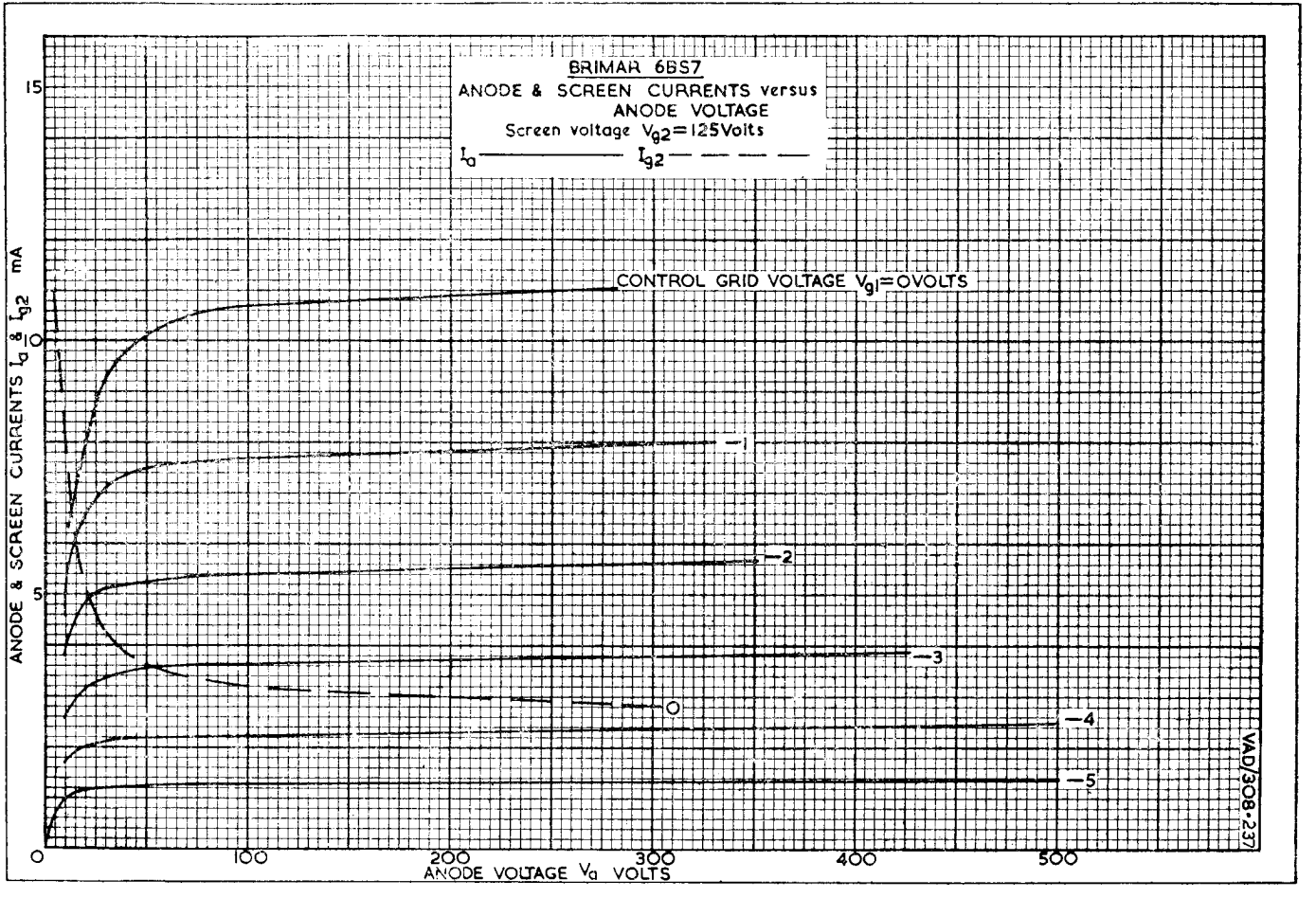
The shot noise in the 6BS7 has been reduced to a minimum by careful design, and the noise due to leakage controlled by careful assembly and inspection. A certain amount of leakage noise is unavoidable in a mass produced valve, and this reveals itself as a small variation in noise level from valve to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

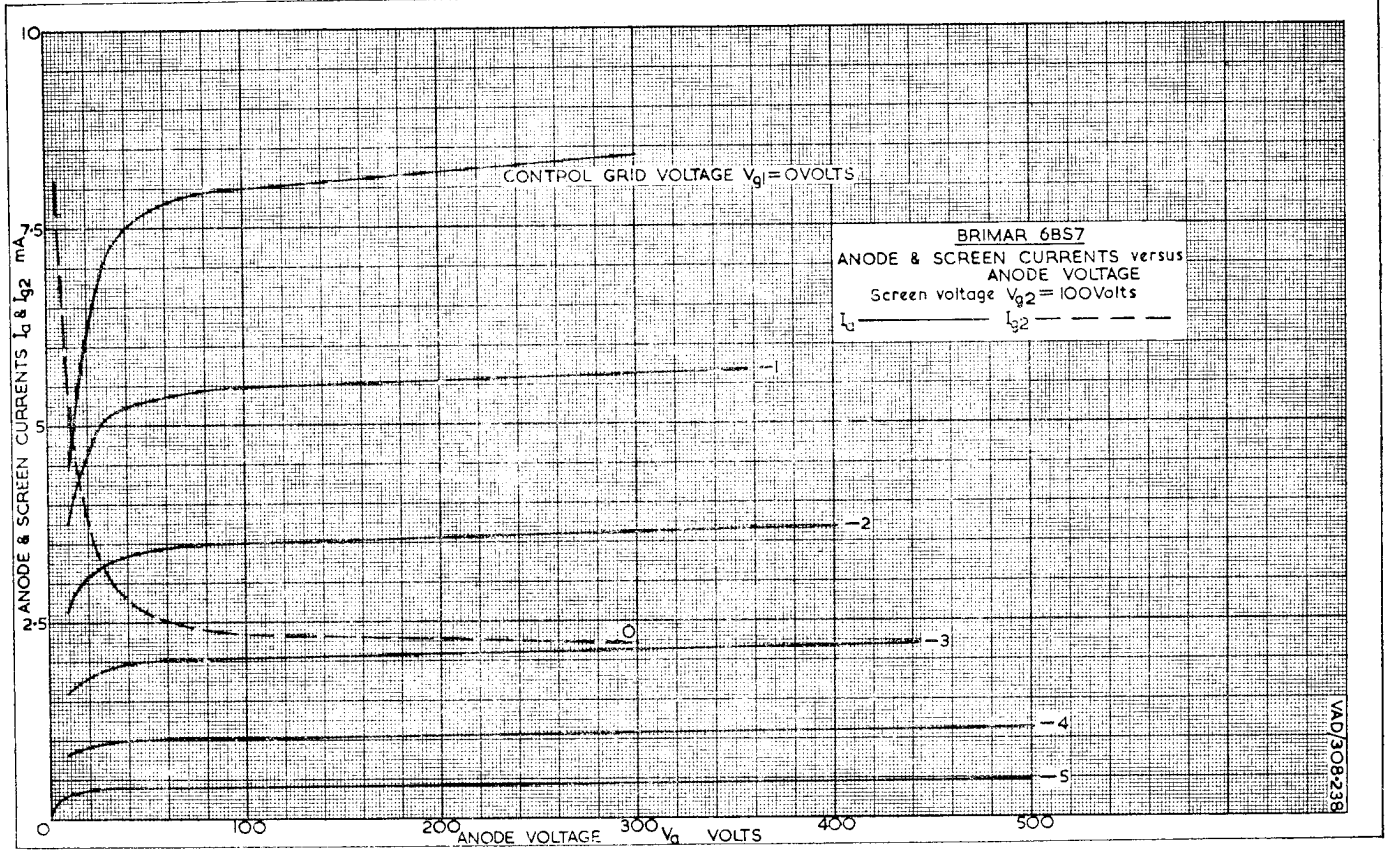
The Curve No. 308·250 shows the maximum hiss voltage plotted against the percentage of valves, using a grid resistor of 100 kΩ and a bandwidth of 10 kc/s. The curve is very steep, and indicates that a hiss level on the grid always lower than 7μV is to be expected.

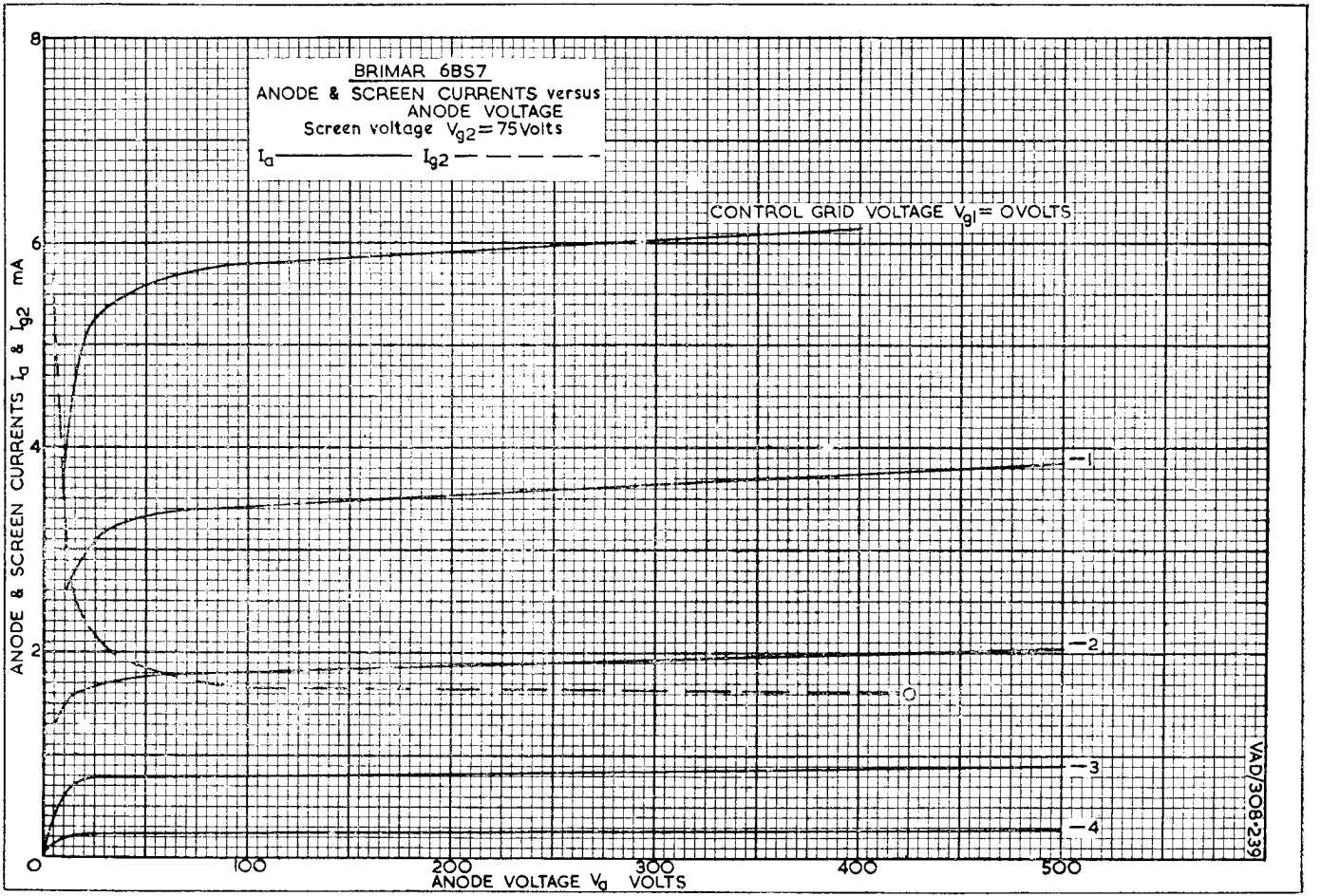
The Curve No. 308·251 shows the same parameters with the valve triode connected. Here partition noise has been eliminated. As would be expected the higher noise levels are unaltered because they are due mainly to leakage which is not greatly affected by whether the valve is triode or pentode connected. 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.

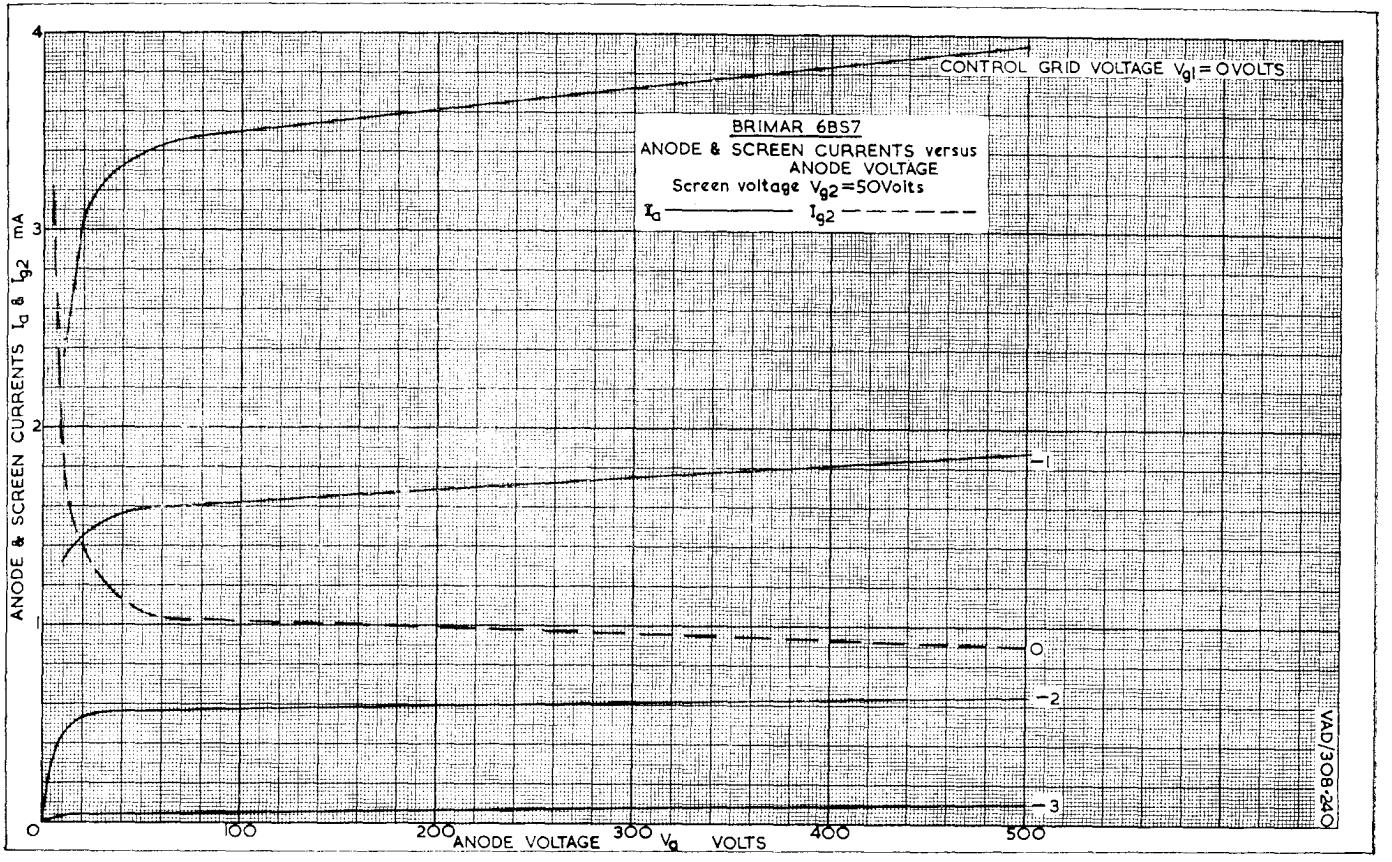
9.0 Other Applications: By virtue of the precautions taken to ensure low grid leakage, the 6BS7 may be of use where a valve with exceptionally low control grid current is required and the use of a special electrometer valve is not warranted. Curve No. 308·254 shows the maximum control grid current plotted 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.

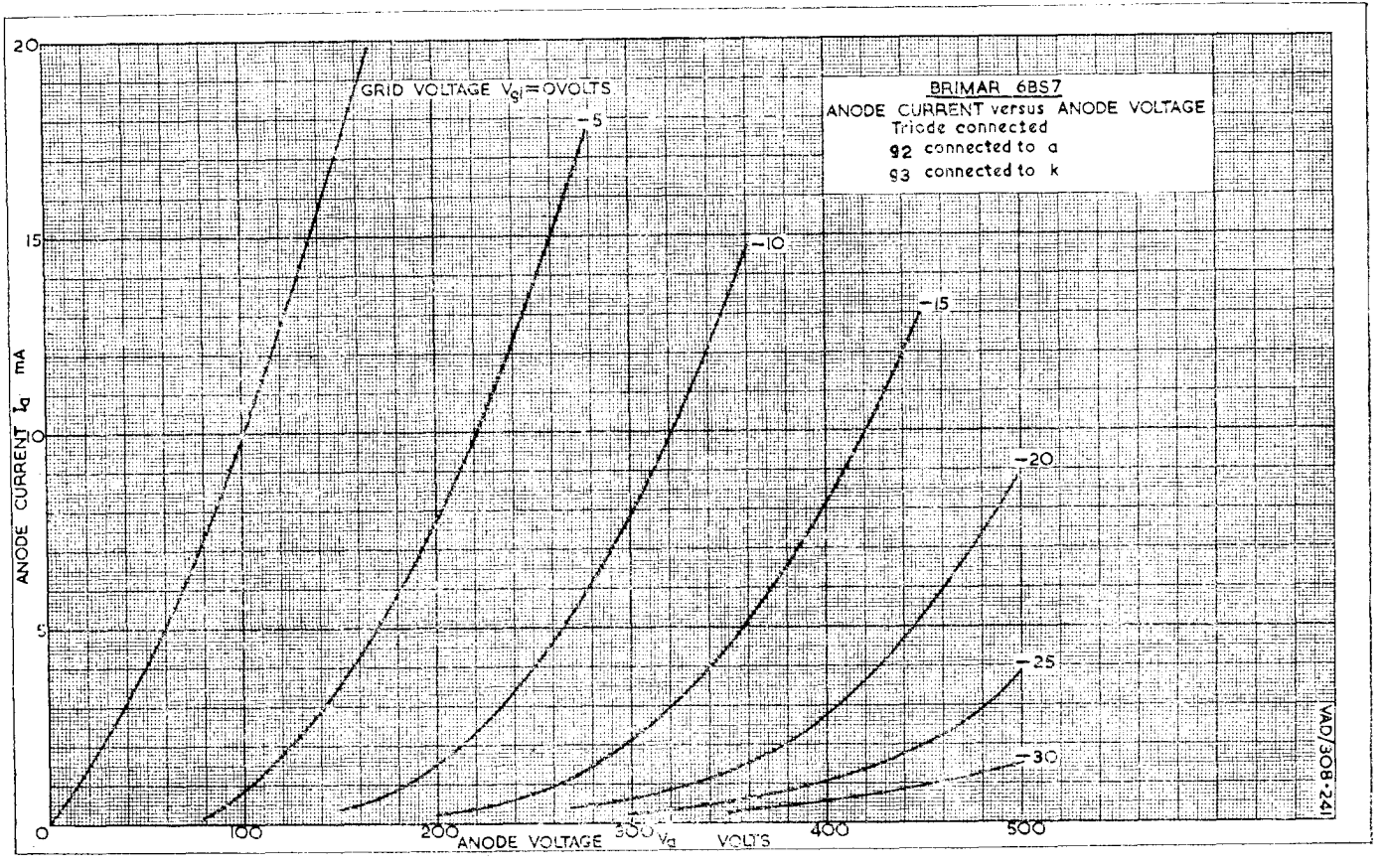
The value of grid current is affected, in the case of valves with lowest leakage, by incident light due to stray photo-emission. The figures quoted are for normal room daylight, and some improvement may be obtained by shielding the valve from incident light.

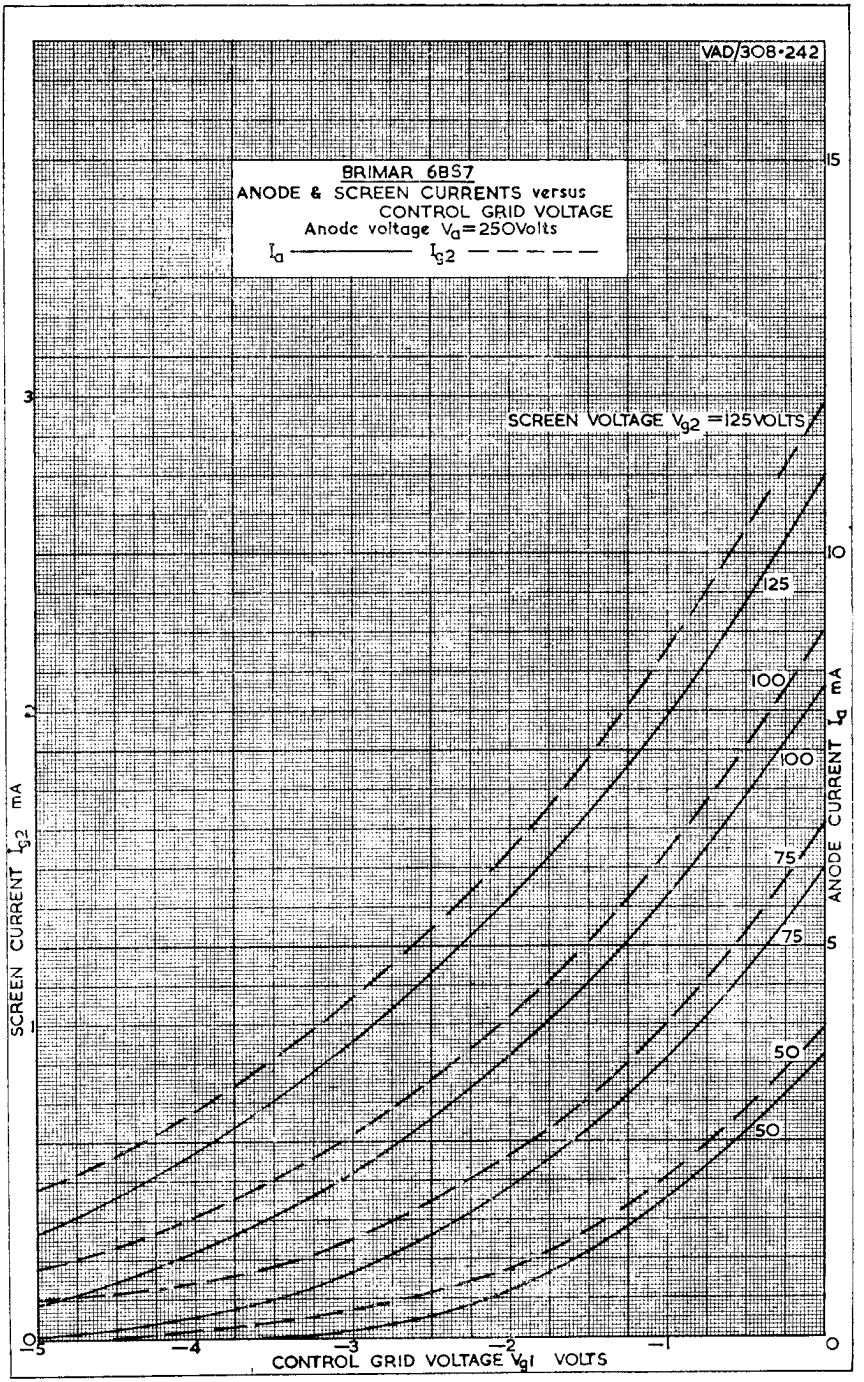

BRIMAR 6BS7
ANODE & SCREEN CURRENTS versus ANODE VOLTAGE
Screen voltage V_{g2}=125Volts
I_a —— I_{g2} — — —
CONTROL GRID VOLTAGE V_{g1}=0VOLTS
-1
-2
-3
0
-4
-5
ANODE & SCREEN CURRENTS I_a & I_{g2} mA
ANODE VOLTAGE V_a VOLTS
0
5
10
15
100
200
300
400
500
VAD/308-237

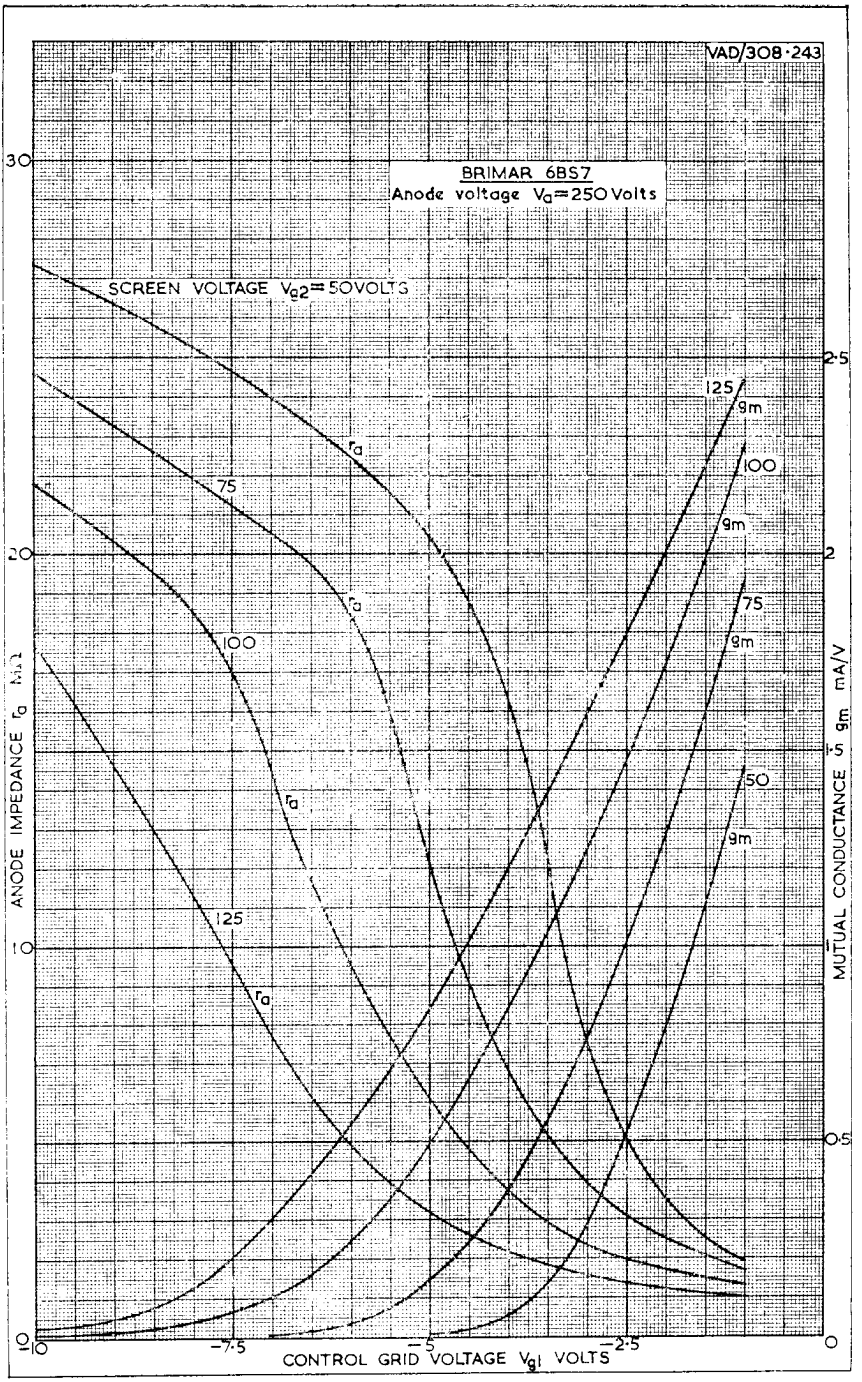

BRIMAR 6BS7
ANODE & SCREEN CURRENTS versus ANODE VOLTAGE
Screen voltage V_{g2} = 100 Volts
I_a ——— I_{g2} — — — —
CONTROL GRID VOLTAGE V_{g1} = 0 VOLTS
-1
-2
-0
-3
-4
-5
ANODE & SCREEN CURRENTS I_a & I_{g2} mA
ANODE VOLTAGE V_a VOLTS
0
2·5
5
7·5
10
100
200
300
400
500
VAD/308-238

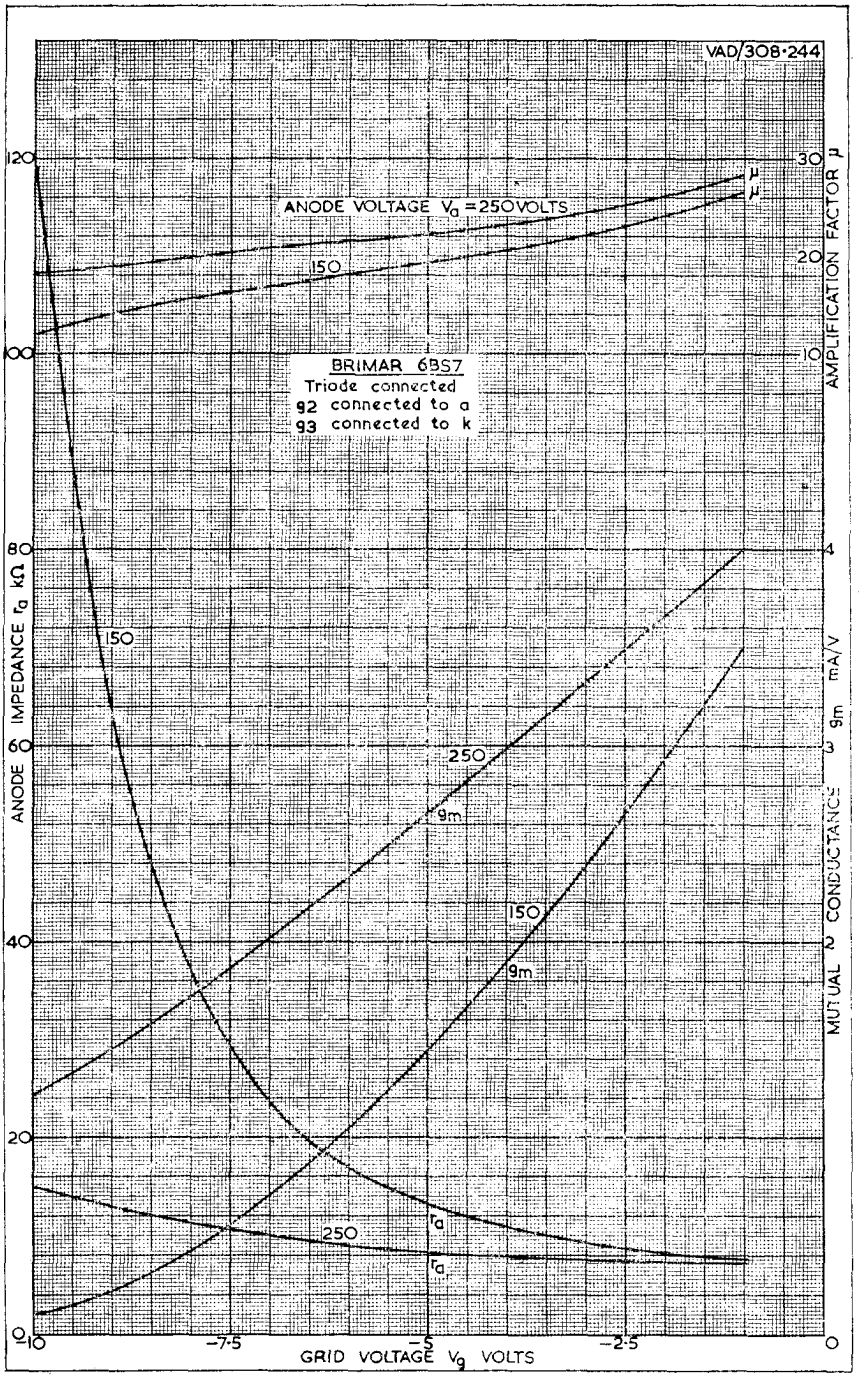

BRIMAR 6BS7
ANODE & SCREEN CURRENTS versus ANODE VOLTAGE
Screen voltage V_{g2} = 75 Volts
I_a ——— I_{g2} — — — —
CONTROL GRID VOLTAGE V_{g1} = 0 VOLTS
-1
-2
0
-3
-4
ANODE & SCREEN CURRENTS I_a & I_{g2} mA
ANODE VOLTAGE V_a VOLTS
0
100
200
300
400
500
2
4
6
8
VAD/308-239

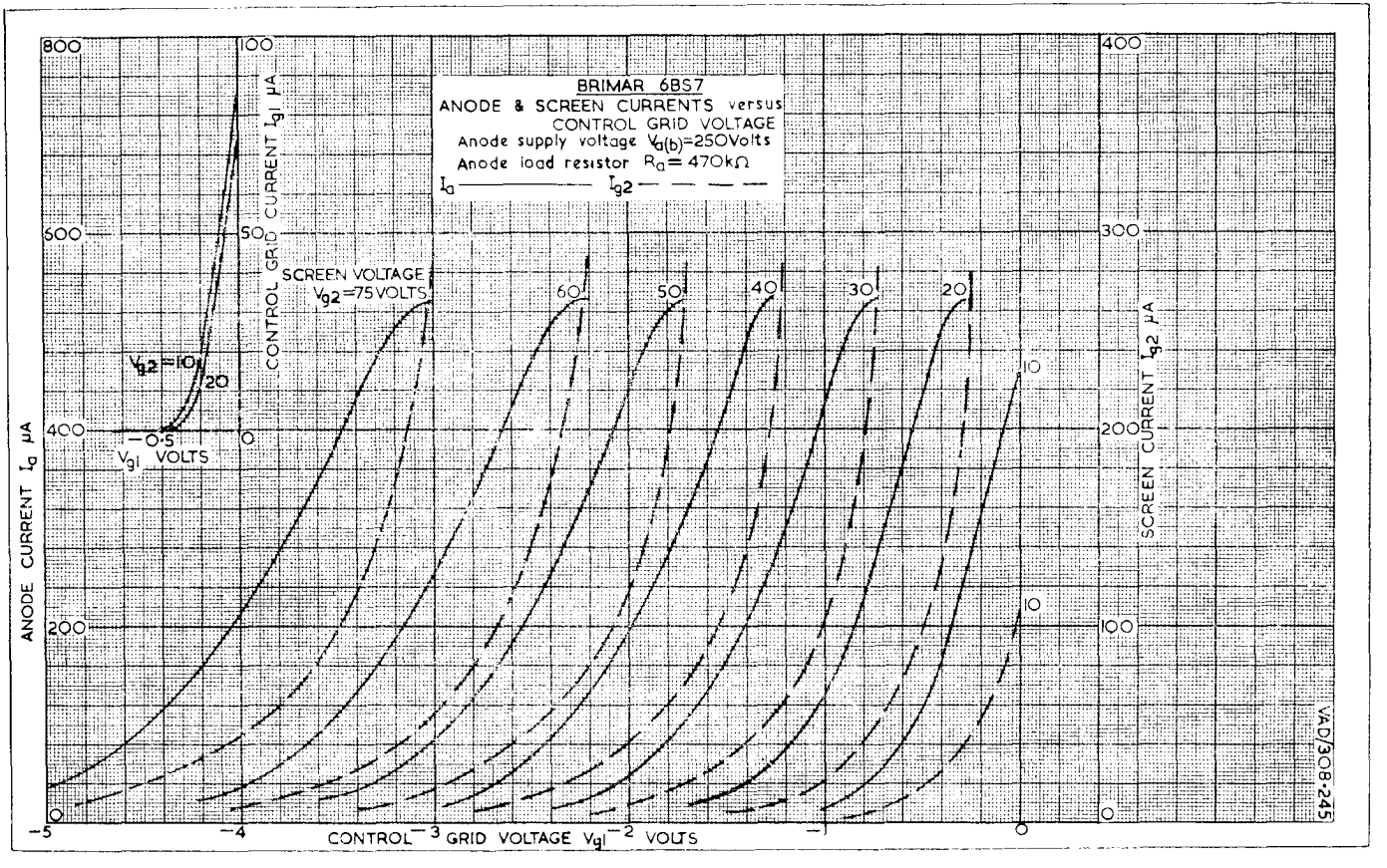

BRIMAR 6BS7
ANODE & SCREEN CURRENTS versus ANODE VOLTAGE
Screen voltage V_{g2}=50Volts
I_a ——— I_{g2} – – – – –
CONTROL GRID VOLTAGE V_{g1} = 0 VOLTS
-1
0
-2
-3
ANODE & SCREEN CURRENTS I_a & I_{g2} mA
ANODE VOLTAGE V_a VOLTS
0
100
200
300
400
500
1
2
3
4
VAD/308-240

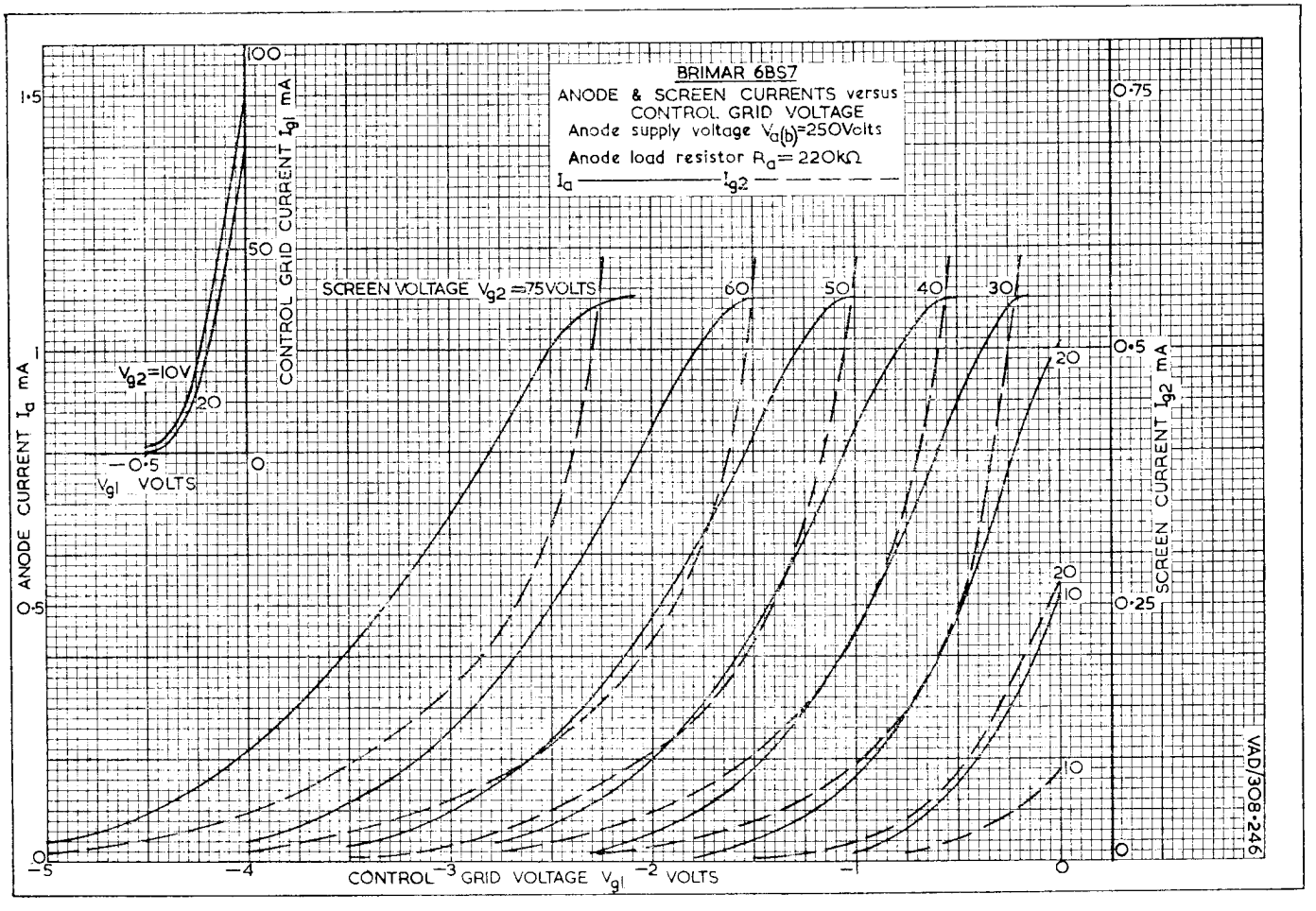

BRIMAR 6BS7
ANODE CURRENT versus ANODE VOLTAGE
Triode connected
g2 connected to a
g3 connected to k
GRID VOLTAGE V_{g1} = 0 VOLTS
-5
-10
-15
-20
-25
-30
ANODE CURRENT I_a mA
ANODE VOLTAGE V_a VOLTS
0
5
10
15
20
100
200
300
400
500
VA0/300-9-241

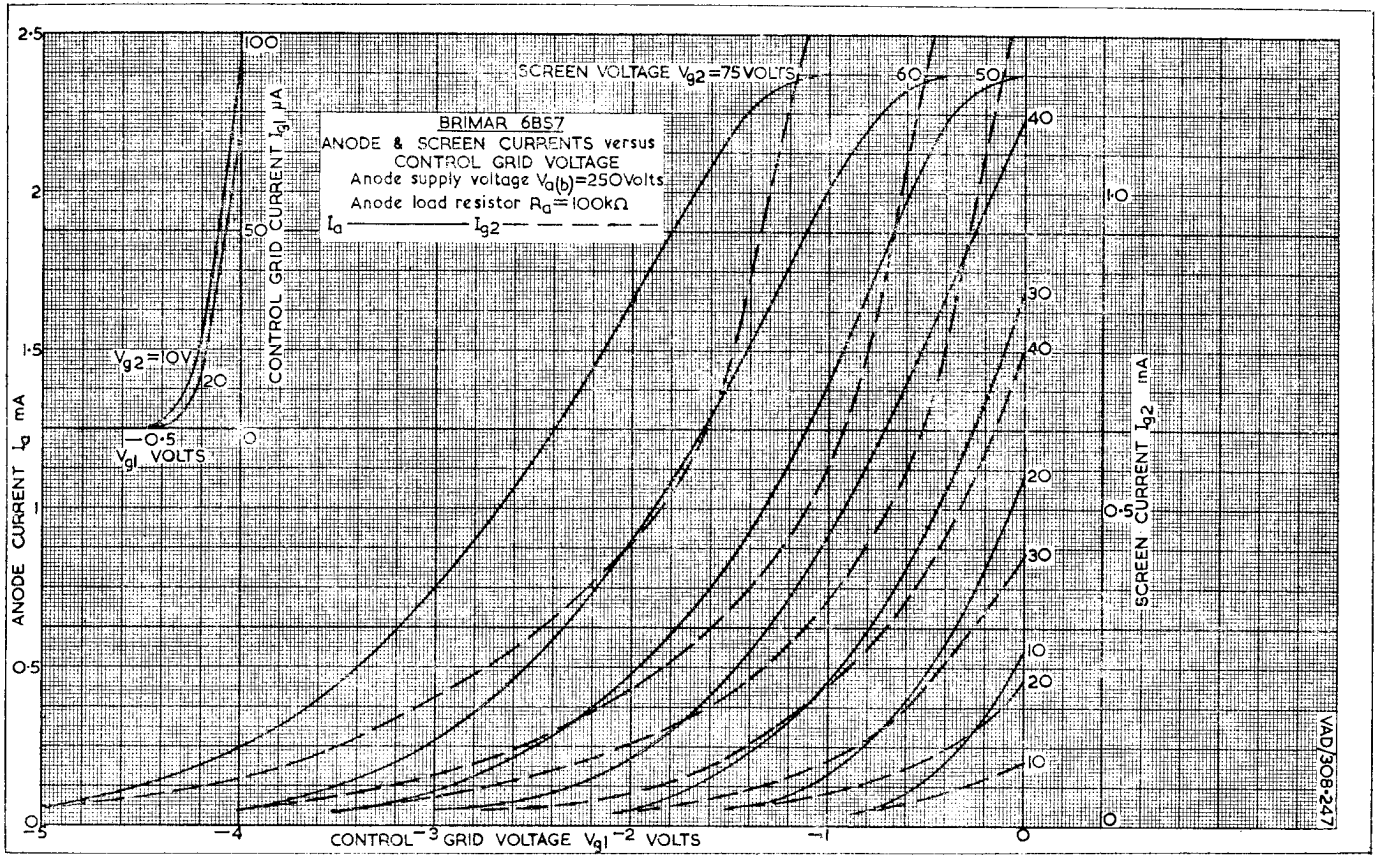

VAD/308·242
BRIMAR 6BS7
ANODE & SCREEN CURRENTS versus
CONTROL GRID VOLTAGE
Anode voltage V_a=250Volts
I_a ——— I_{g2} — — — —
SCREEN VOLTAGE V_{g2} =125VOLTS
125
100
100
75
75
50
50
SCREEN CURRENT I_{g2} mA
ANODE CURRENT I_a mA
CONTROL GRID VOLTAGE V_{g1} VOLTS
0
1
2
3
5
10
15
−5
−4
−3
−2
−1
0

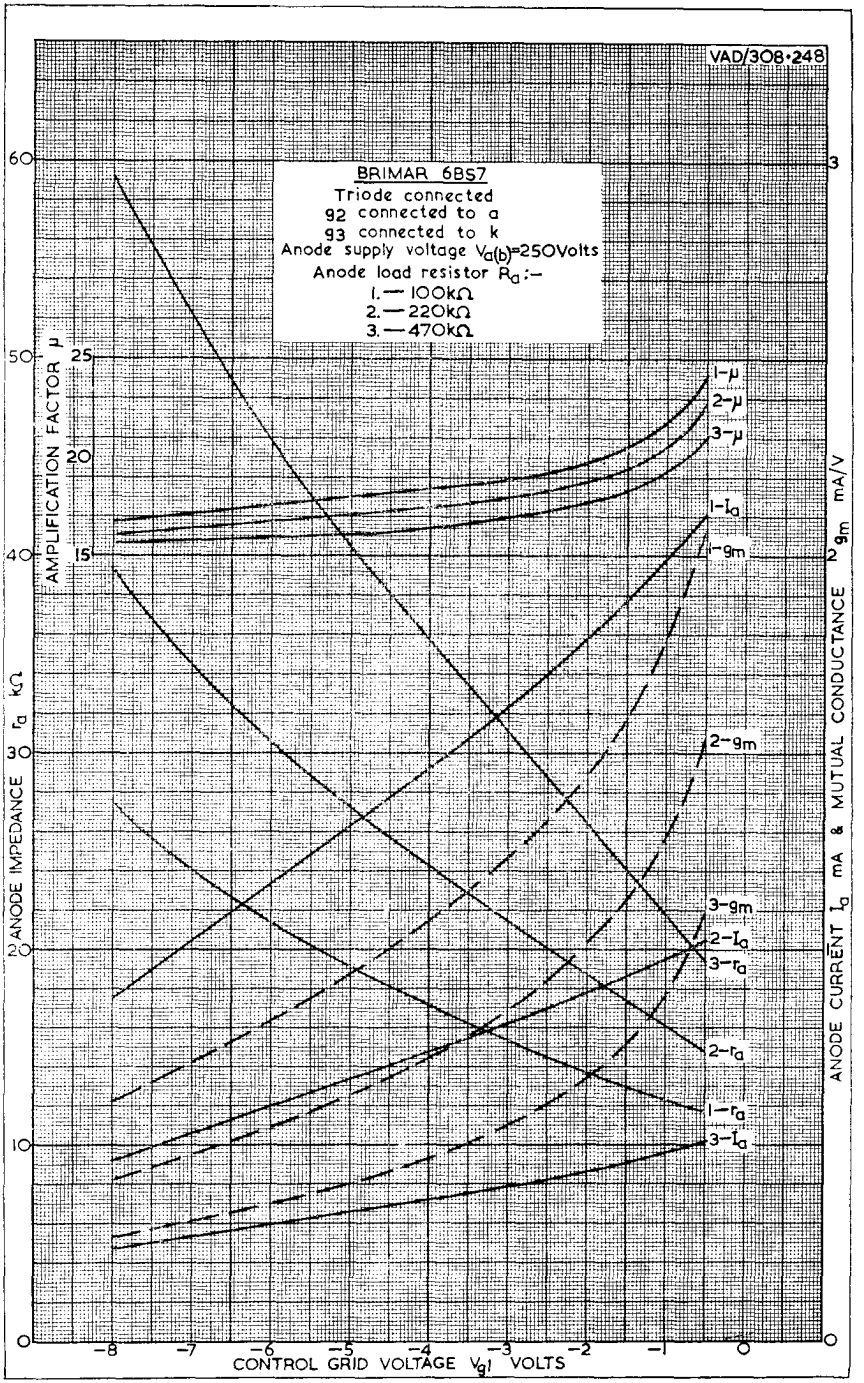

VAD/308·243
BRIMAR 6BS7
Anode voltage V_a=250 Volts
SCREEN VOLTAGE V_{g2}=50VOLTS
ANODE IMPEDANCE r_a MΩ
MUTUAL CONDUCTANCE g_m mA/V
CONTROL GRID VOLTAGE V_{g1} VOLTS
3·0
2·0
1·0
0
2·5
2
1·5
1
0·5
0
−10
−7·5
−5
−2·5
125
100
75
50
r_a
g_m

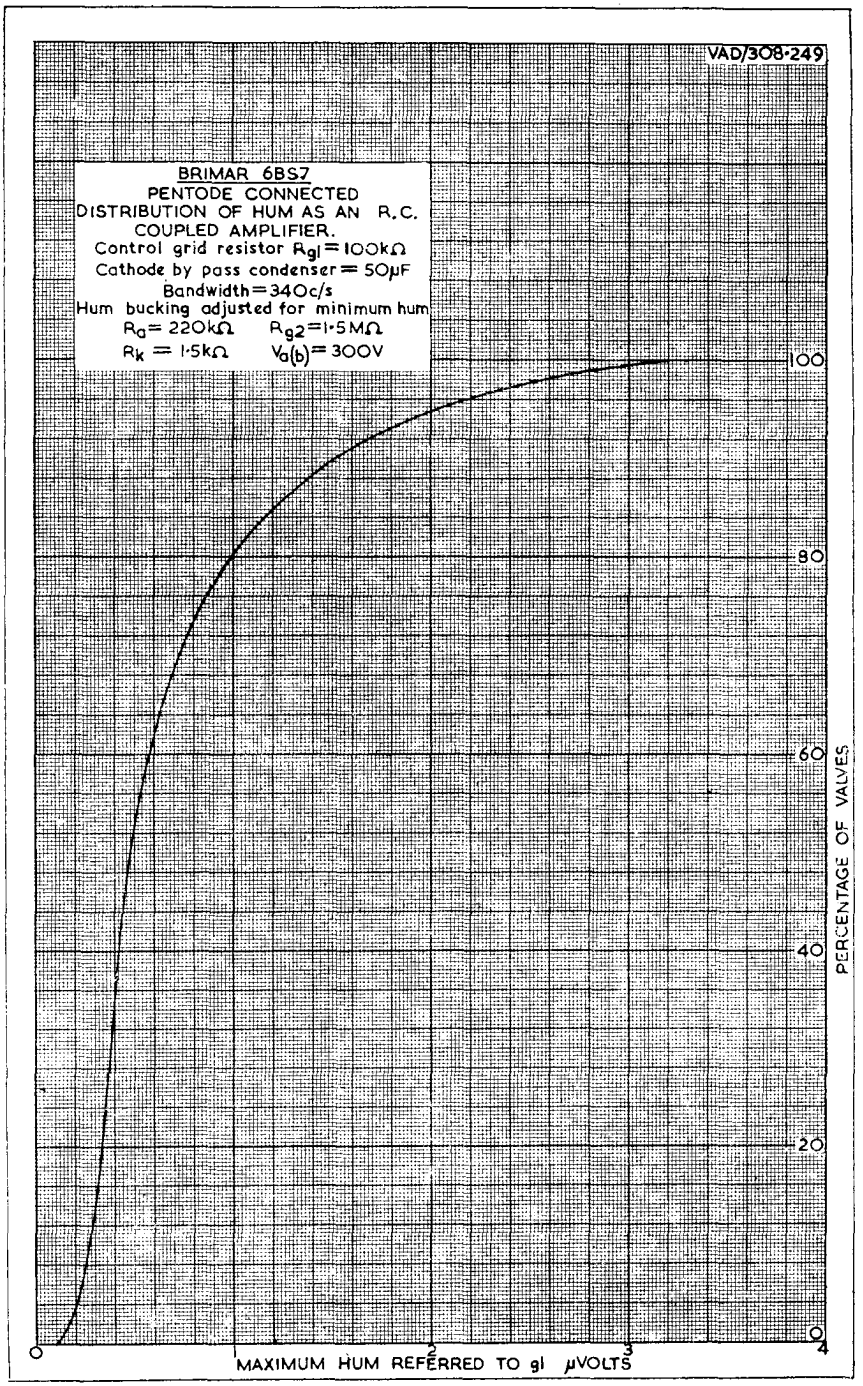

VAD/308·244
ANODE VOLTAGE V_a = 250 VOLTS
μ
μ
150
BRIMAR 6BS7
Triode connected
g2 connected to a
g3 connected to k
150
250
g_m
150
g_m
250
r_a
r_a
ANODE IMPEDANCE r_a kΩ
MUTUAL CONDUCTANCE g_m mA/V
AMPLIFICATION FACTOR μ
GRID VOLTAGE V_g VOLTS
120
100
80
60
40
20
0
30
20
10
4
3
2
0
−10
−7·5
−5
−2·5
0

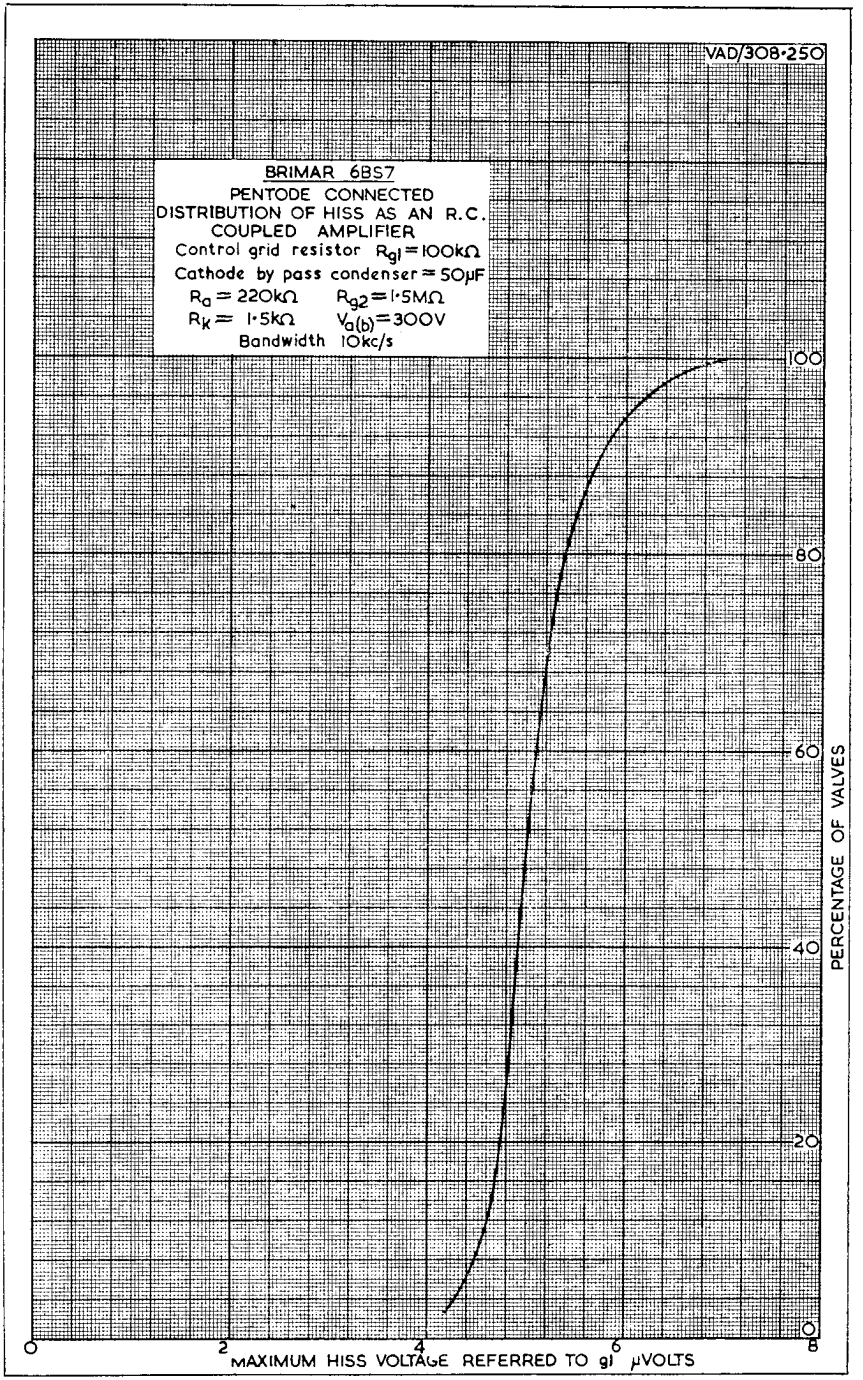

BRIMAR 6BS7
ANODE & SCREEN CURRENTS versus
CONTROL GRID VOLTAGE
Anode supply voltage $V_{a(b)}$=250Volts
Anode load resistor R_a= 470kΩ
I_a ——— I_{g2} — — — —
SCREEN VOLTAGE
V_{g2}=75VOLTS
60
50
40
30
20
V_{g2}=10
20
−0·5
V_{g1} VOLTS
ANODE CURRENT I_a μA
CONTROL GRID CURRENT I_{g1} μA
SCREEN CURRENT I_{g2} μA
CONTROL GRID VOLTAGE V_{g1} VOLTS
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
1·5
1
0·5
0
ANODE CURRENT I_a mA
0·75
0·5
0·25
0
SCREEN CURRENT I_{g2} mA
−5
−4
−3
−2
−1
0
CONTROL GRID VOLTAGE V_{g1} VOLTS
VAD/308·246


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

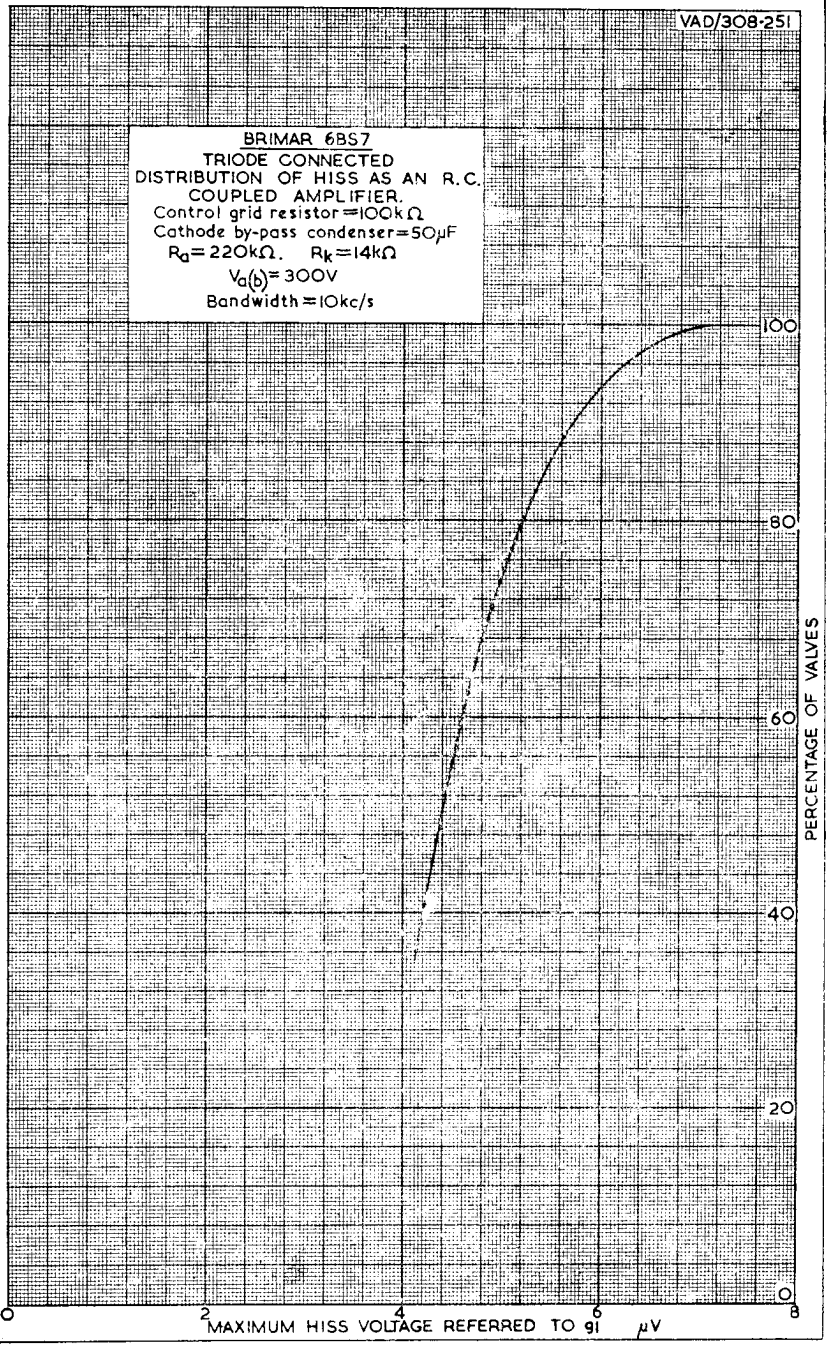

VAD/308·248
BRIMAR 6BS7
Triode connected
g2 connected to a
g3 connected to k
Anode supply voltage Va(b)=250Volts
Anode load resistor Ra :-
1. — 100kΩ
2. — 220kΩ
3. — 470kΩ
AMPLIFICATION FACTOR μ
ANODE IMPEDANCE ra kΩ
ANODE CURRENT Ia mA & MUTUAL CONDUCTANCE gm mA/V
CONTROL GRID VOLTAGE Vg1 VOLTS
1-μ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

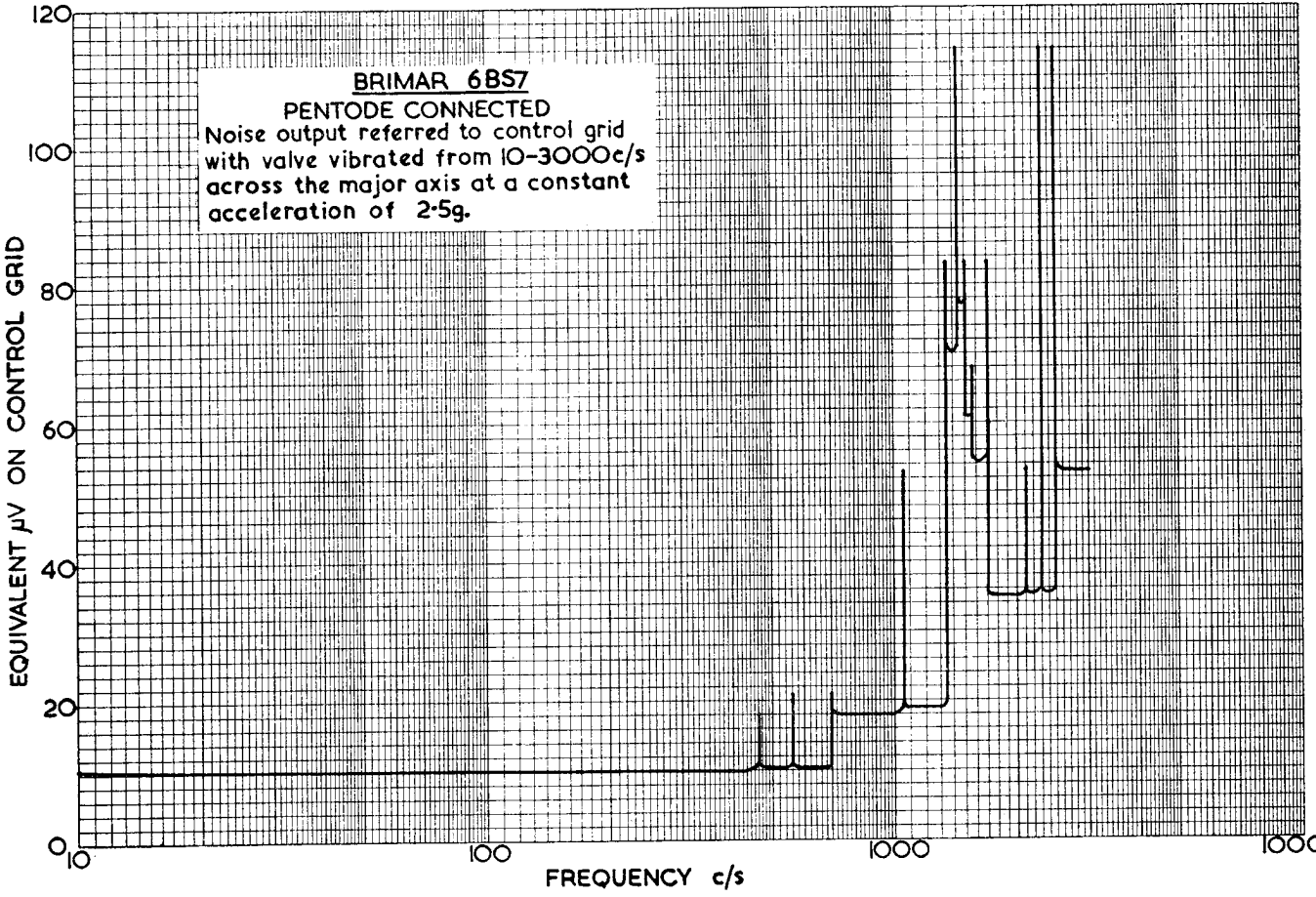

VAD/308-249
BRIMAR 6BS7
PENTODE CONNECTED
DISTRIBUTION OF HUM AS AN R.C.
COUPLED AMPLIFIER.
Control grid resistor R_{g1} = 100kΩ
Cathode by pass condenser = 50μF
Bandwidth = 340c/s
Hum bucking adjusted for minimum hum
R_a = 220kΩ R_{g2} = 1·5MΩ
R_k = 1·5kΩ $V_{a(b)}$ = 300V
100
80
60
40
20
0
PERCENTAGE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

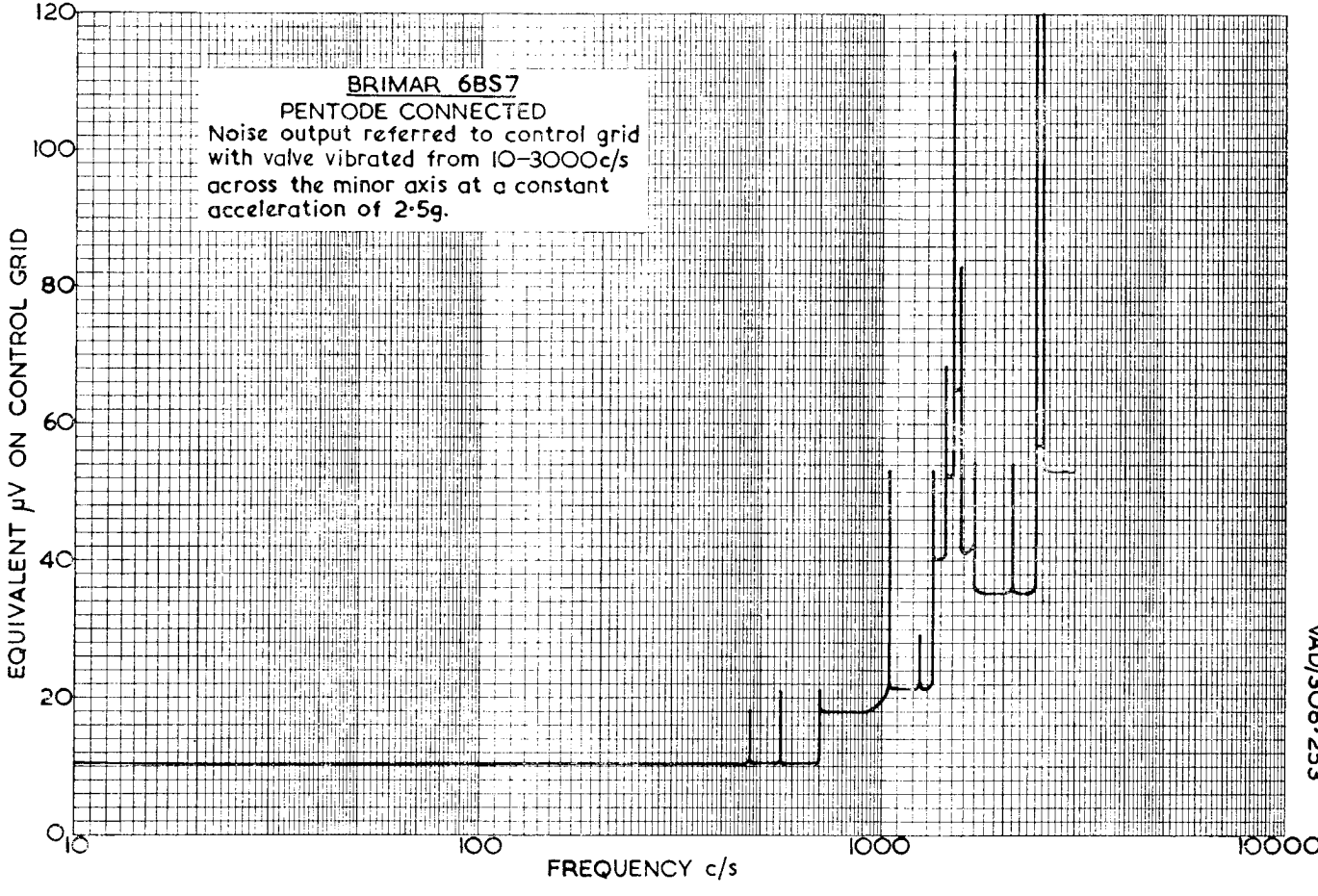

VAD/308·250
BRIMAR 6BS7
PENTODE CONNECTED
DISTRIBUTION OF HISS AS AN R.C. COUPLED AMPLIFIER
Control grid resistor R_{g1} = 100kΩ
Cathode by pass condenser = 50μF
R_a = 220kΩ R_{g2} = 1·5MΩ
R_k = 1·5kΩ $V_{a(b)}$ = 300V
Bandwidth 10kc/s
100
80
60
40
20
0
PERCENTAGE OF VALVES
0
2
4
6
8
MAXIMUM HISS VOLTAGE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

VAD/308-251

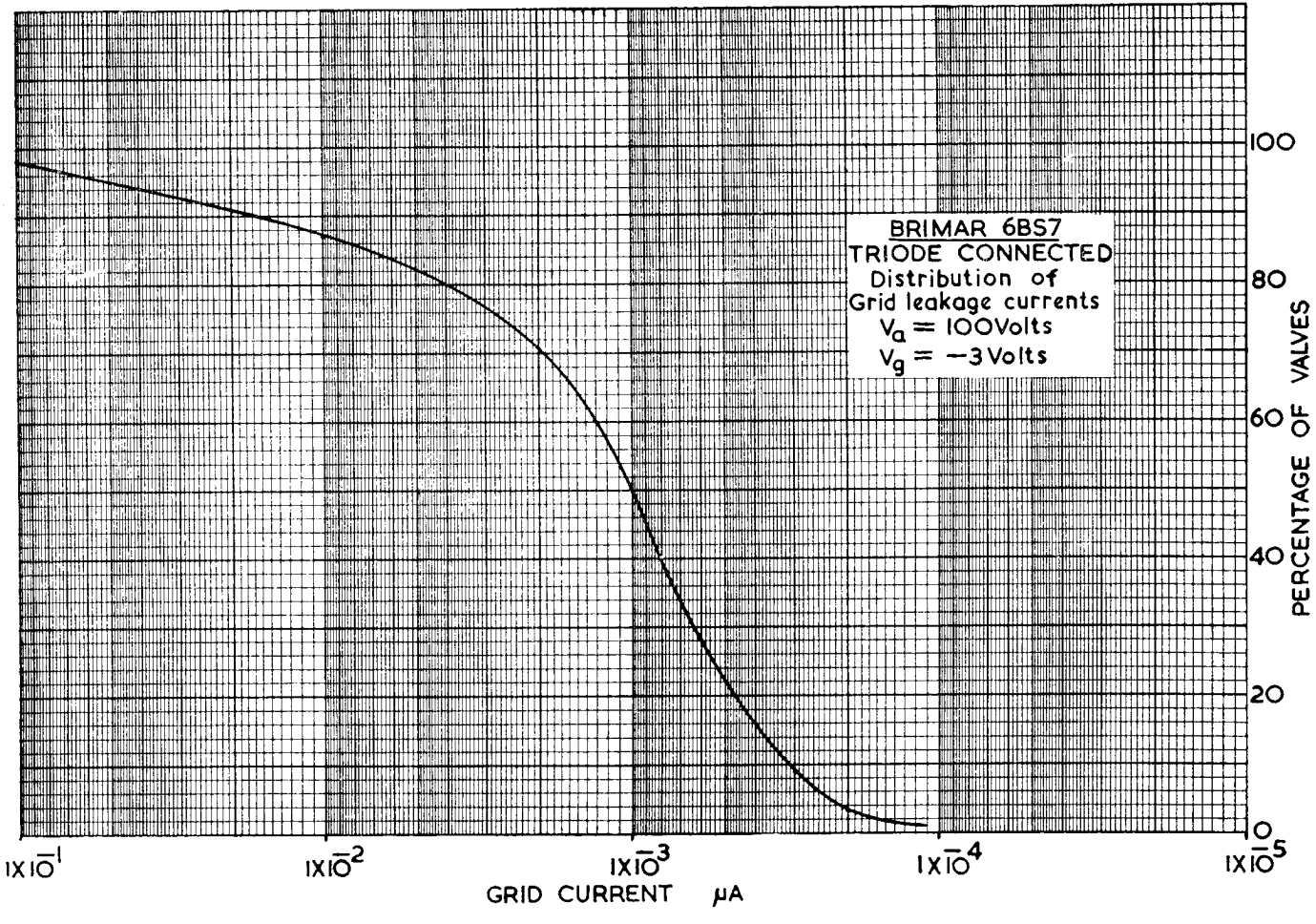
BRIMAR 6BS7
TRIODE CONNECTED
DISTRIBUTION OF HISS AS AN R.C. COUPLED AMPLIFIER.
Control grid resistor = 100kΩ
Cathode by-pass condenser = 50μF
R_a = 220kΩ. R_k = 1.4kΩ
$V_{a(b)}$ = 300V
Bandwidth = 10kc/s




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
$1X10^{-1}$
$1X10^{-2}$
$1X10^{-3}$
$1X10^{-4}$
$1X10^{-5}$
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.

PHYSICAL DATA: 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 AB1 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.

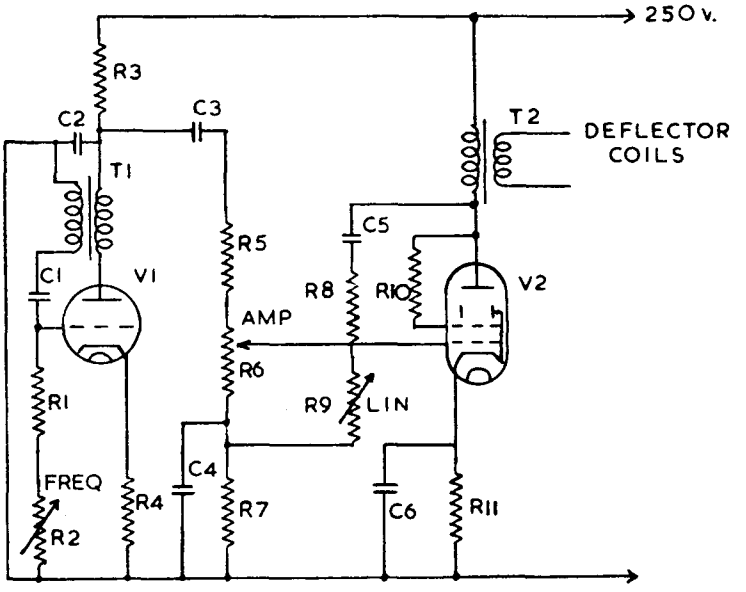
C4 influences the feedback circuit, stretching the top of the picture as it is increased.

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

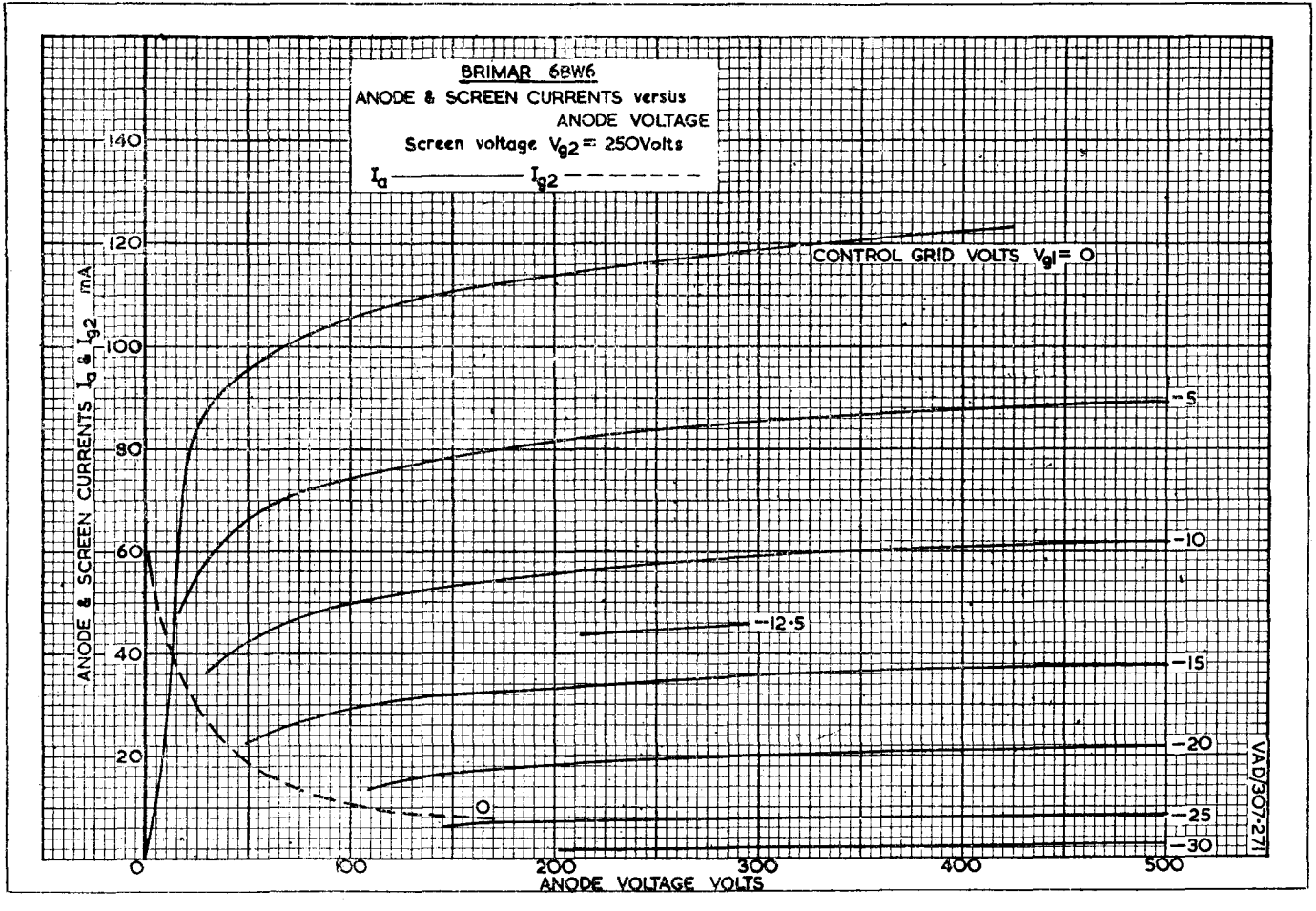
Synchronising pulses may be fed either to the grid or to the anode of the blocking oscillator, depending whether their polarity is positive or negative.

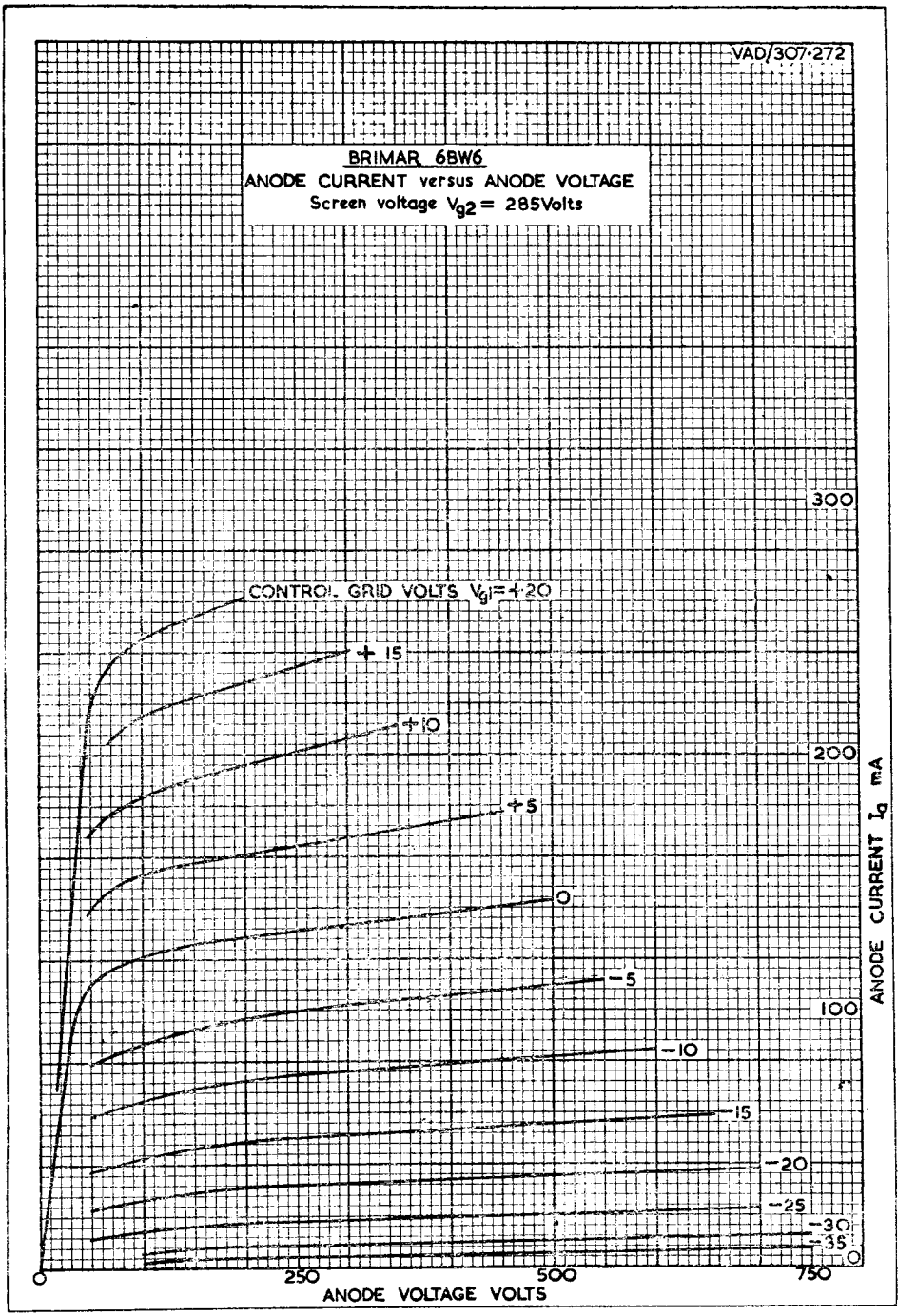
BRIMAR 6BW6

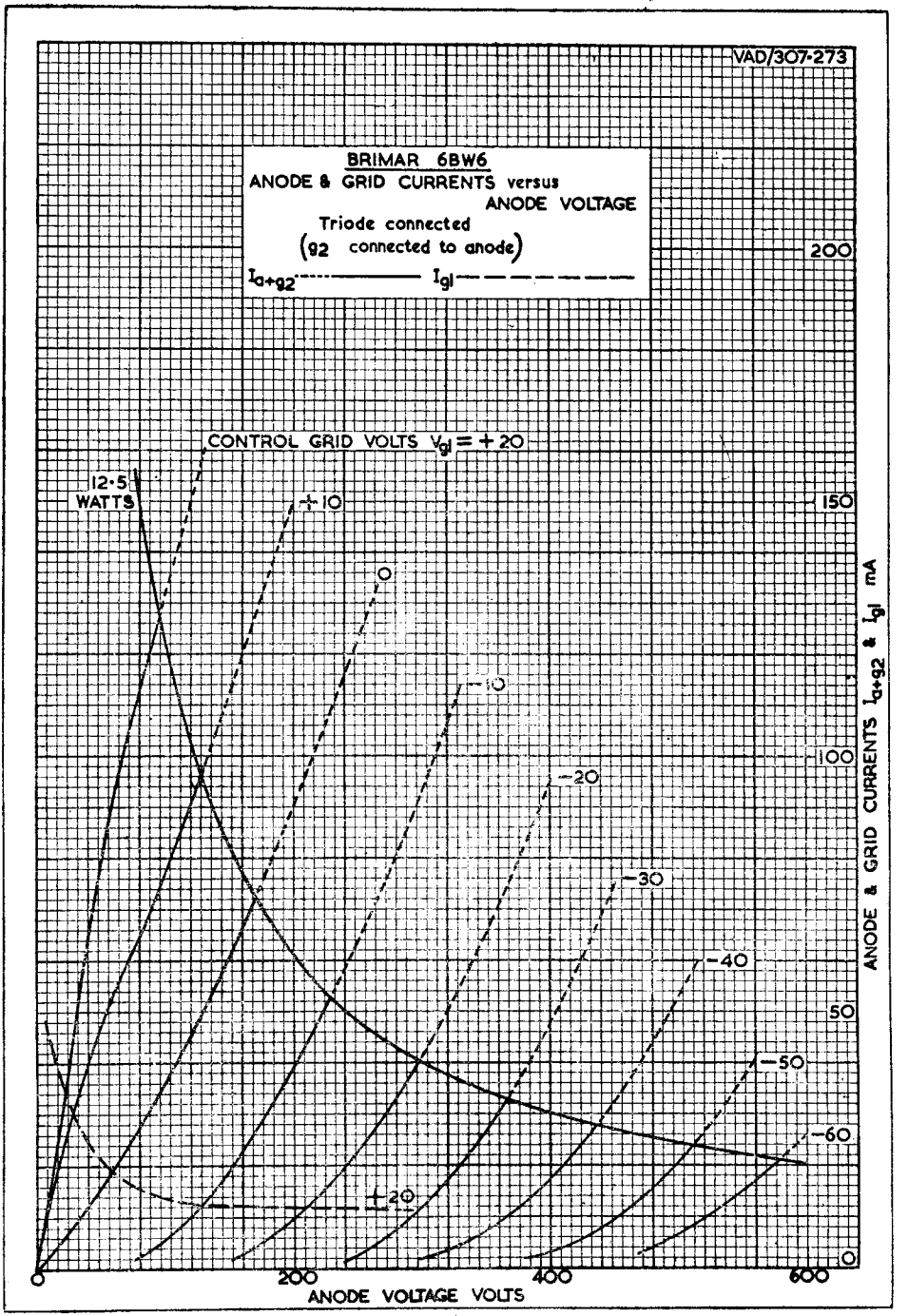
FRAME TIME BASE

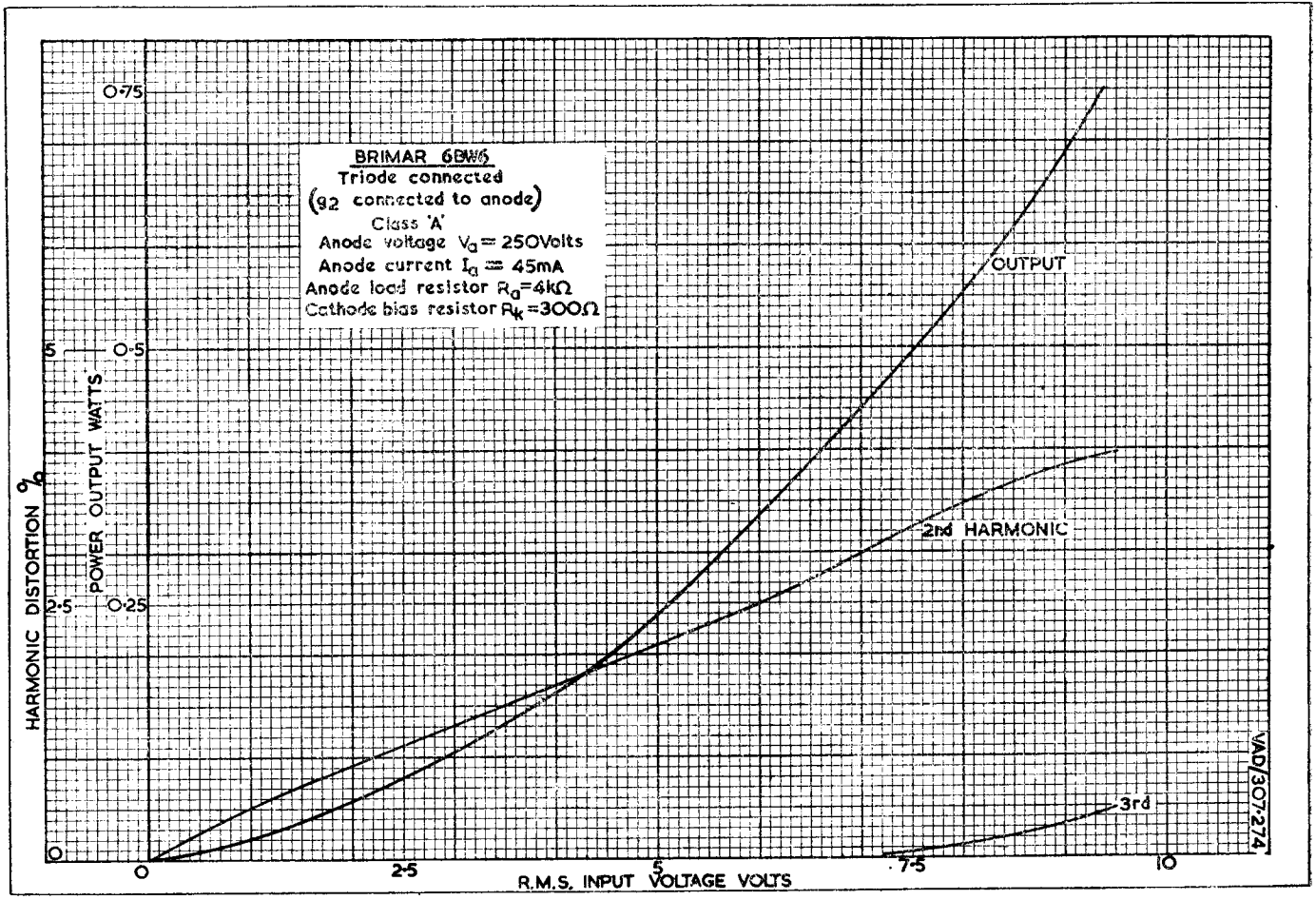


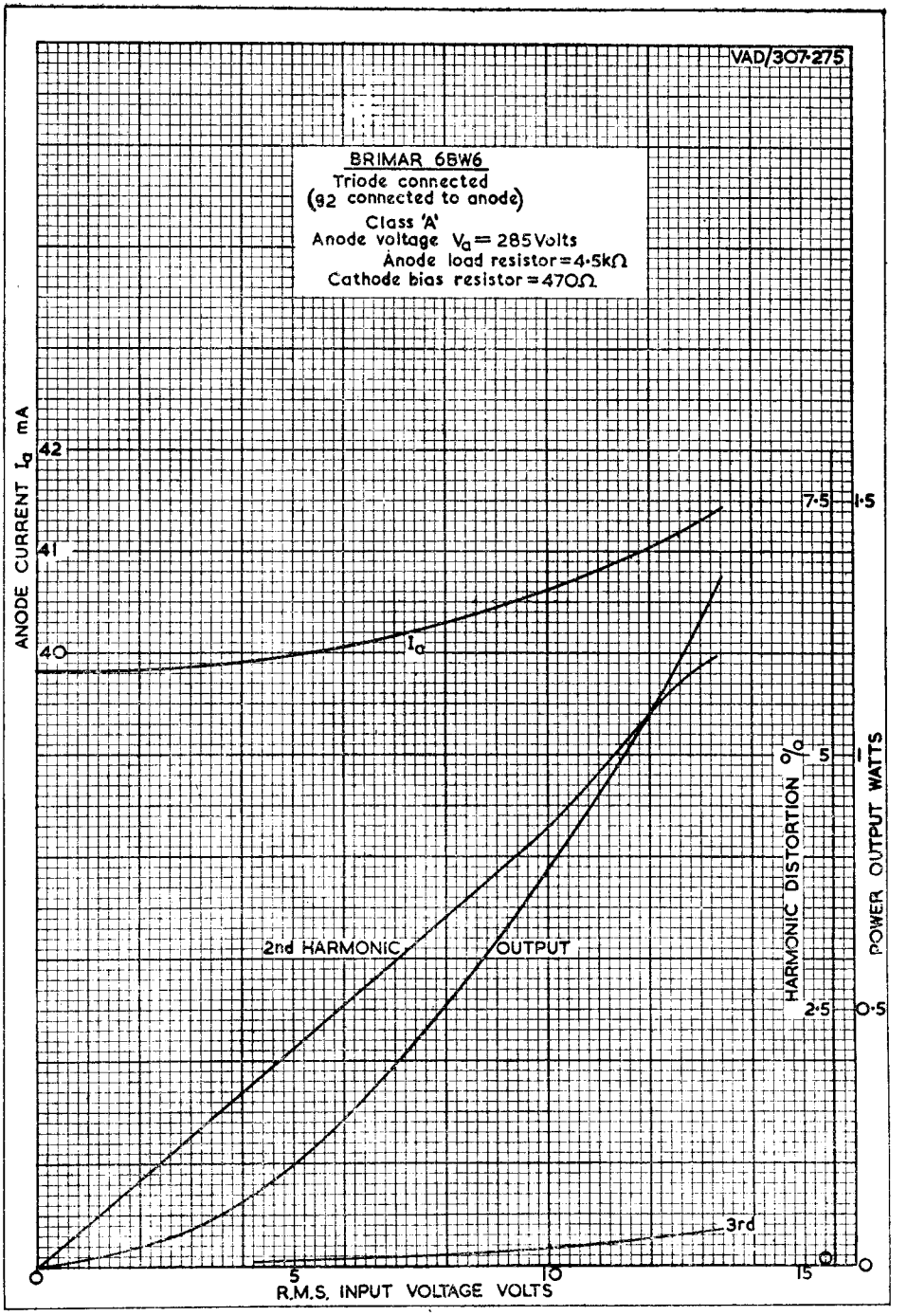
R_1	47 k	C_1	0·5
R_2	100 k var.	C_2	0·1
R_3	470 k	C_3	0·1
R_4	220	C_4	0·005
R_5	330 k	C_5	0·01
R_6	1 M pot.	C_6	30 Electrolytic
R_7	470 k	T_1	Frame Blocking Oscillator Transformer. Plessey CP92553
R_9	250 k var.	T_2	Frame Output Transformer. Plessey CP71956/1
R_{10}	100		Deflector Coils, Plessey CP72419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

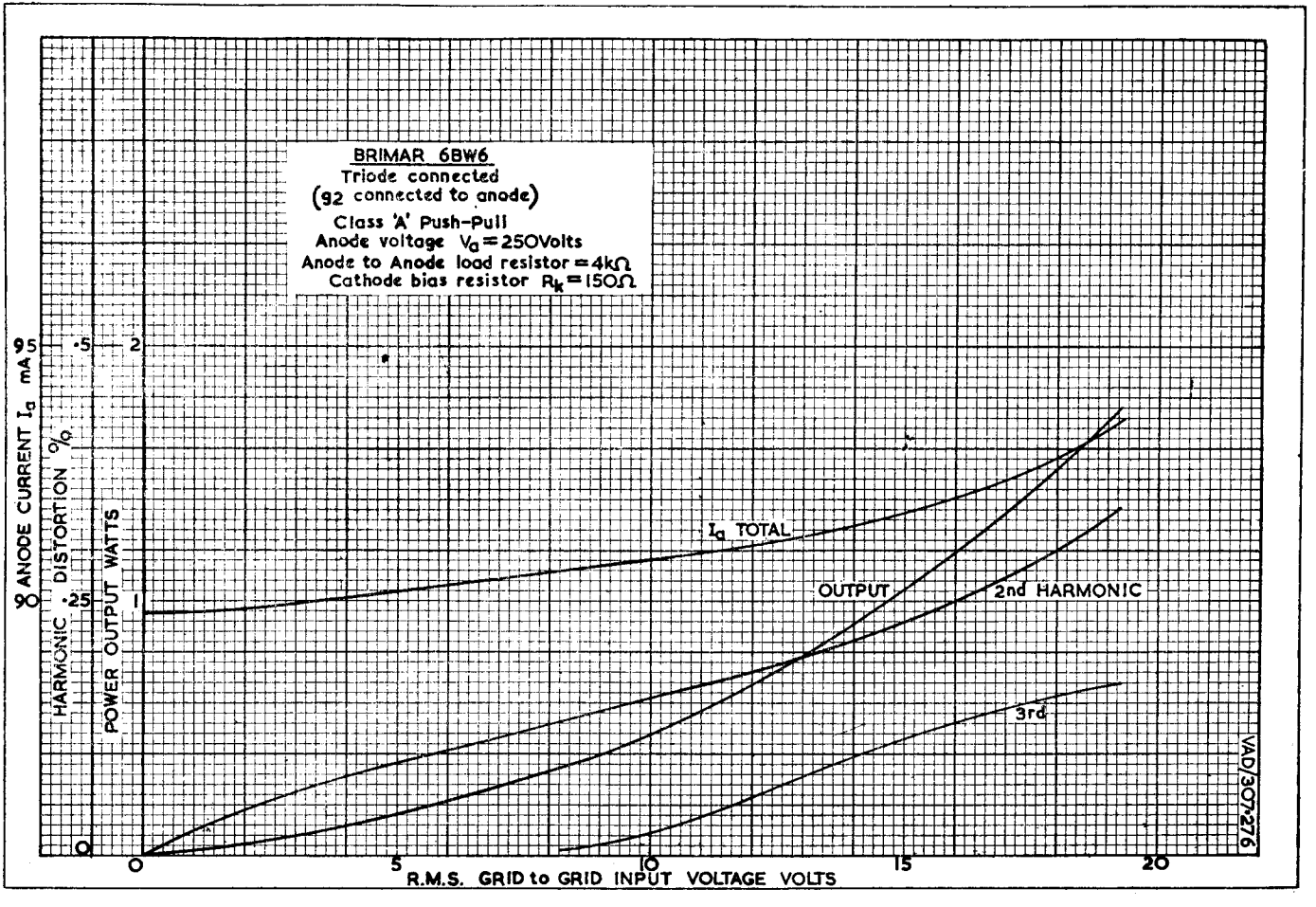

BRIMAR 6BW6
ANODE & SCREEN CURRENTS versus
ANODE VOLTAGE
Screen voltage V_{g2} = 250Volts
I_a ——— I_{g2} - - - - - -
ANODE & SCREEN CURRENTS I_a & I_{g2} mA
140
120
100
80
60
40
20
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
CONTROL GRID VOLTS V_{g1} = 0
-5
-10
-12·5
-15
-20
-25
-30
VAD/307-271

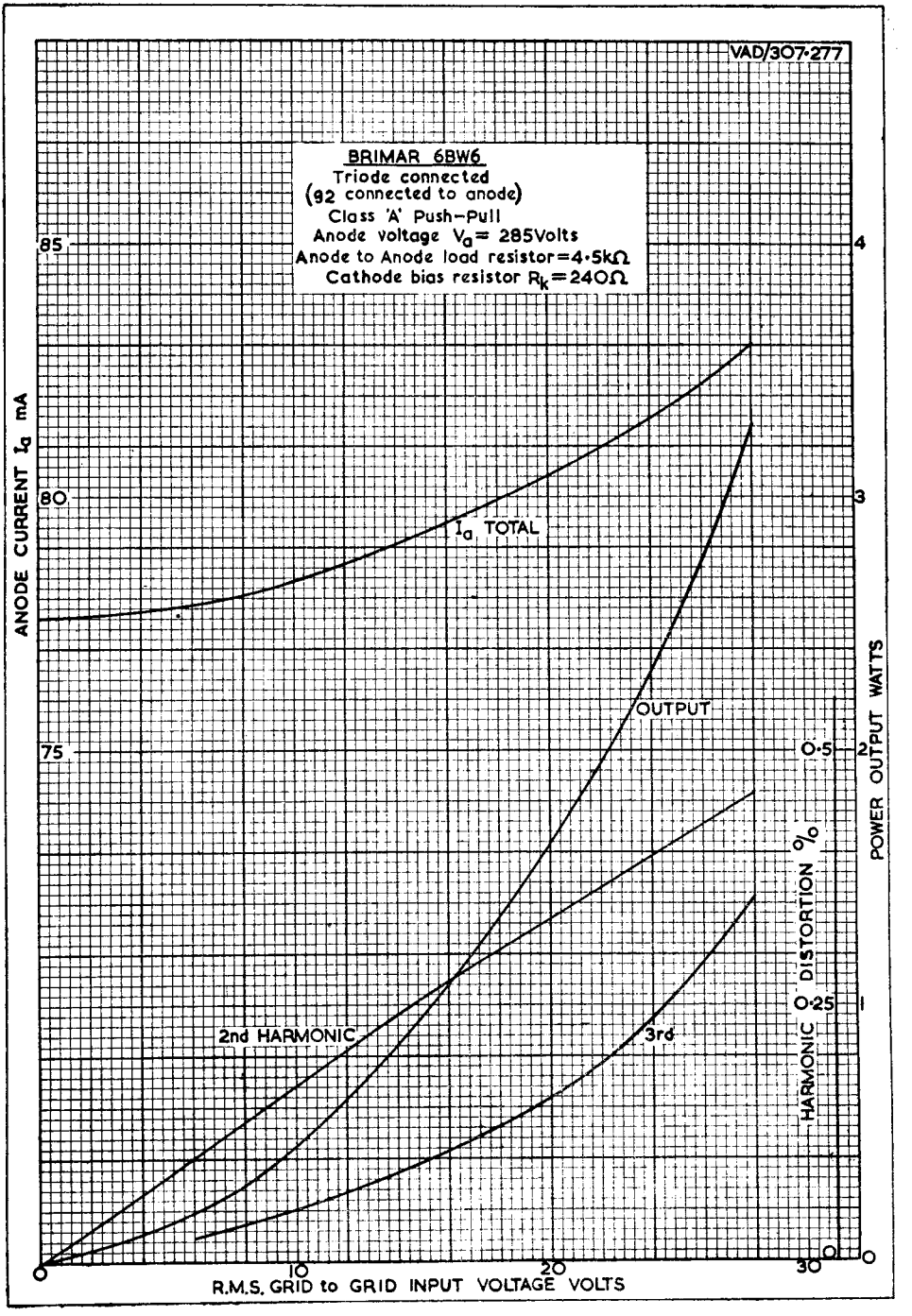

VAD/307·272
BRIMAR 6BW6
ANODE CURRENT versus ANODE VOLTAGE
Screen voltage V_{g2} = 285Volts
CONTROL GRID VOLTS V_{g1}=+20
+15
+10
+5
0
-5
-10
-15
-20
-25
-30
-35
300
200
100
0
250
500
750
ANODE VOLTAGE VOLTS
ANODE CURRENT I_a mA

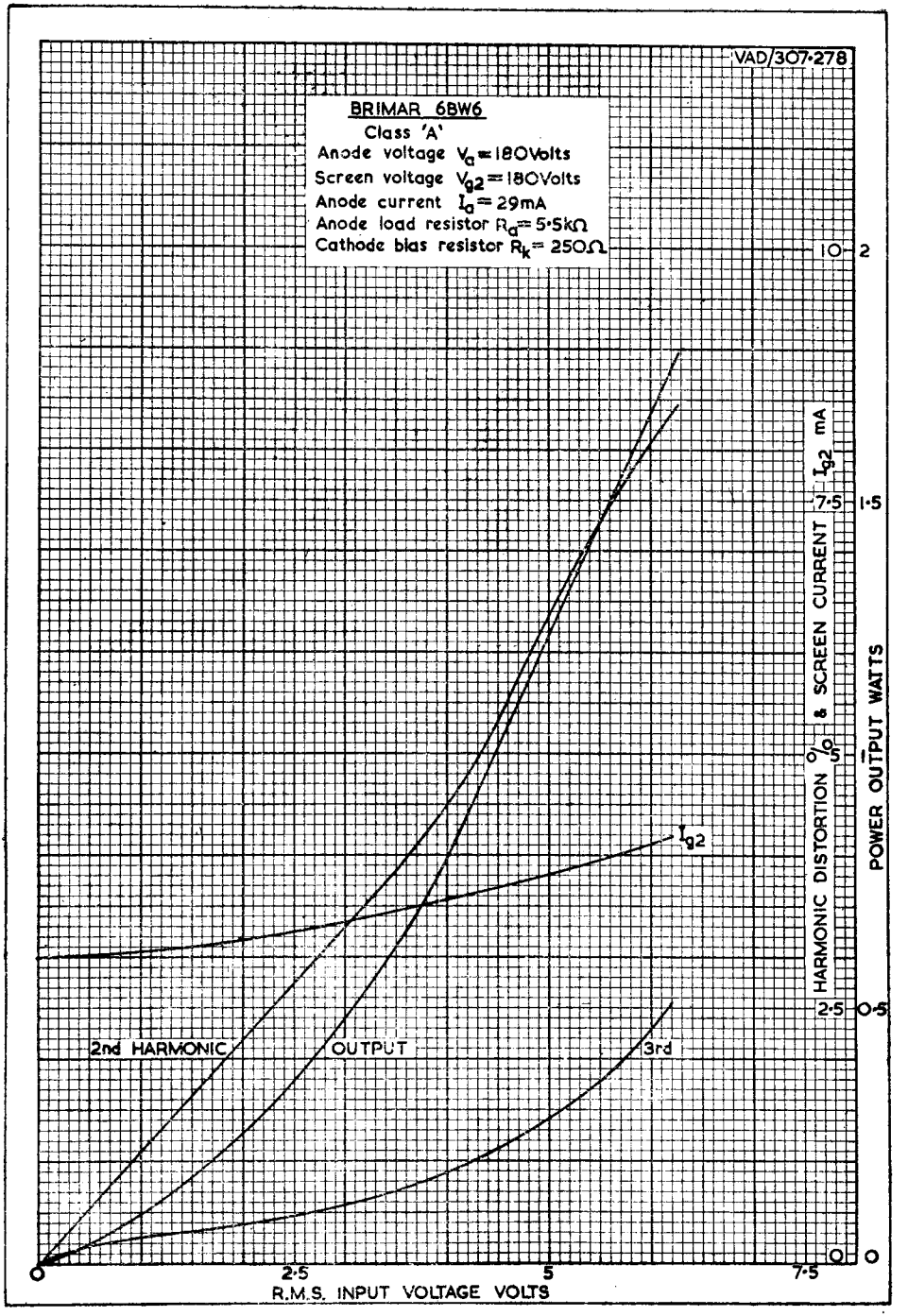

VAD/307-273
BRIMAR 6BW6
ANODE & GRID CURRENTS versus
ANODE VOLTAGE
Triode connected
(g2 connected to anode)
Ia+g2 ---------- Ig1 - - - - - - -
CONTROL GRID VOLTS Vg1 = +20
12·5 WATTS
+10
0
-10
-20
-30
-40
-50
-60
+20
200
150
100
50
0
0
200
400
600
ANODE VOLTAGE VOLTS
ANODE & GRID CURRENTS Ia+g2 & Ig1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

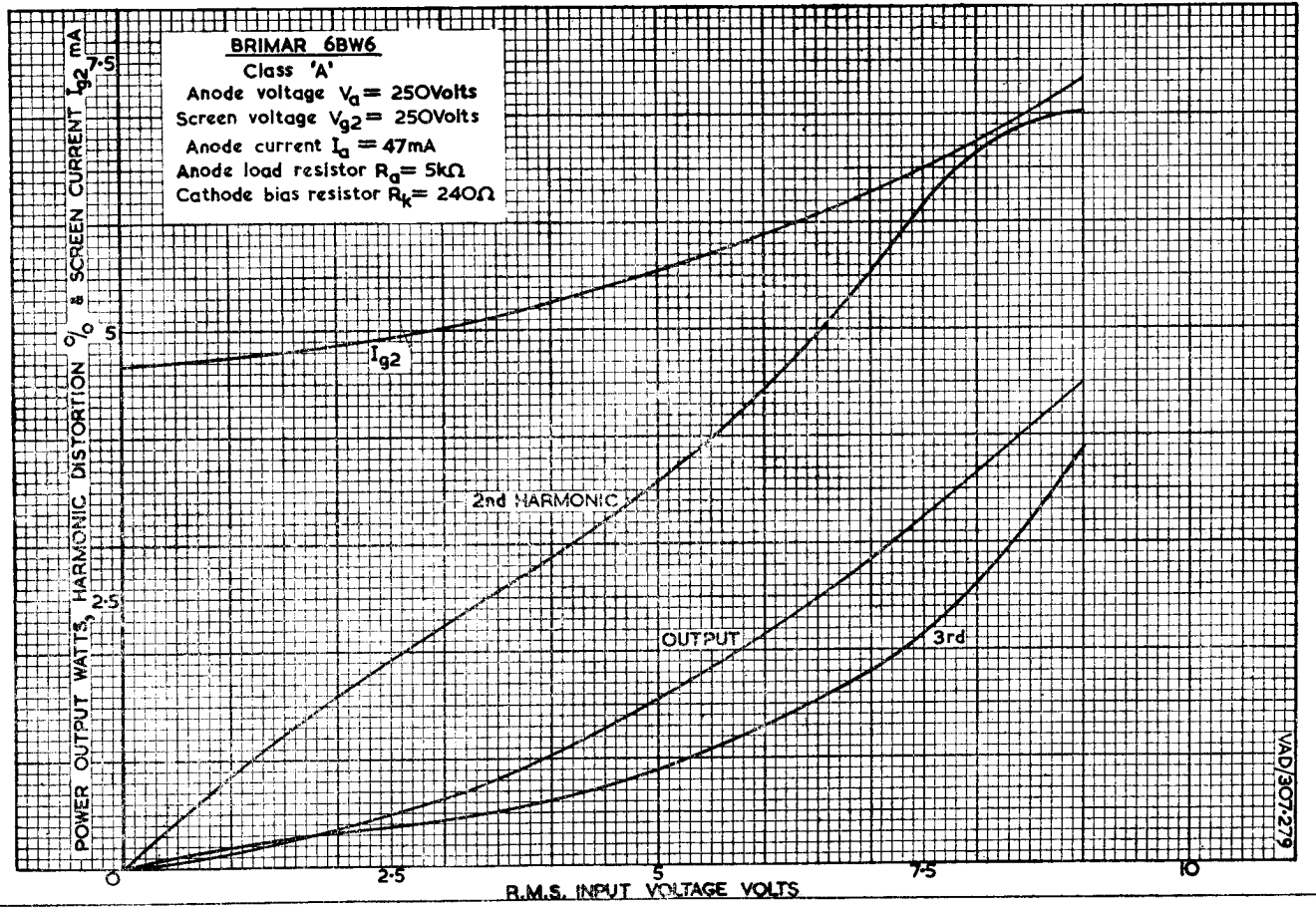

BRIMAR 6BW6
Triode connected
(g2 connected to anode)
Class 'A'
Anode voltage V_a = 250Volts
Anode current I_a = 45mA
Anode load resistor R_a=4kΩ
Cathode bias resistor R_k=300Ω
OUTPUT
2nd HARMONIC
3rd
HARMONIC DISTORTION %
POWER OUTPUT WATTS
R.M.S. INPUT VOLTAGE VOLTS
0·75
0·5
0·25
0
2·5
5
7·5
10
VAD/307·274

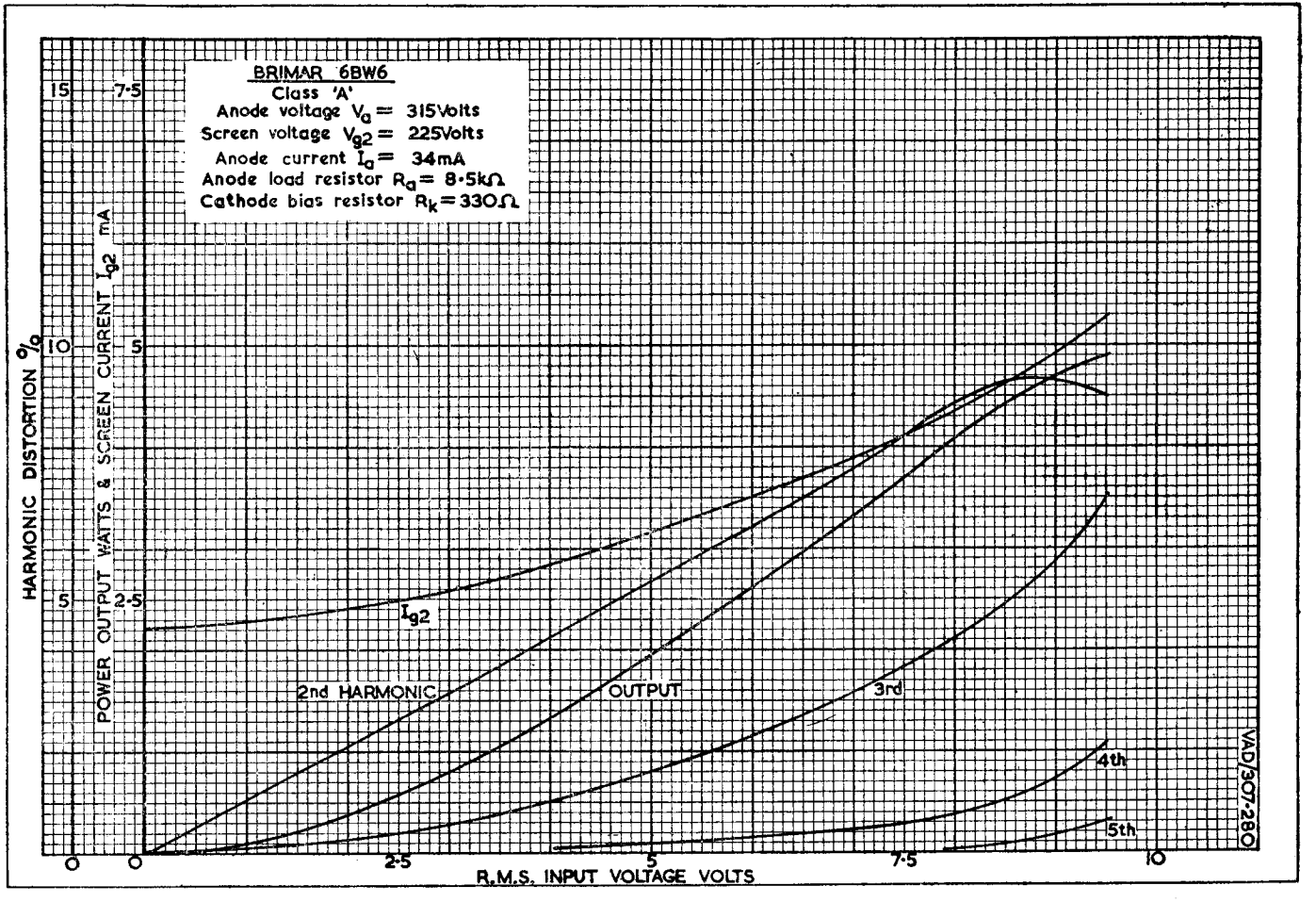

VAD/307-275
BRIMAR 6BW6
Triode connected
(g2 connected to anode)
Class 'A'
Anode voltage V_a = 285 Volts
Anode load resistor = 4·5kΩ
Cathode bias resistor = 470Ω
ANODE CURRENT I_a mA
42
41
40
I_a
7·5
1·5
5
2·5
0·5
0
HARMONIC DISTORTION %
POWER OUTPUT WATTS
2nd HARMONIC
OUTPUT
3rd
0
5
10
15
R.M.S. INPUT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

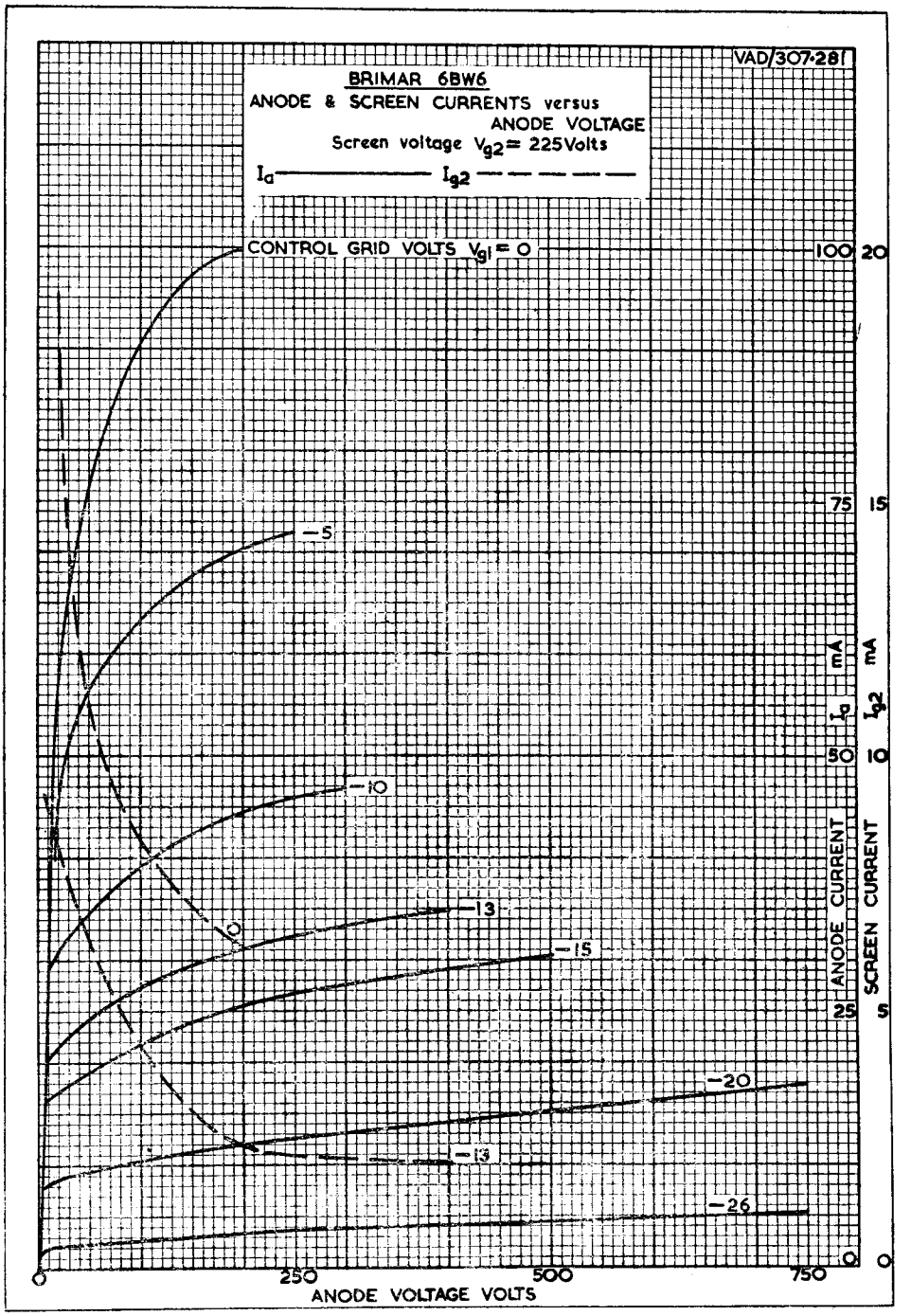

BRIMAR 6BW6
Triode connected
(g2 connected to anode)
Class 'A' Push-Pull
Anode voltage V_a = 250Volts
Anode to Anode load resistor = 4kΩ
Cathode bias resistor R_k = 150Ω
95
90
ANODE CURRENT I_a mA
HARMONIC DISTORTION %
·5
·25
0
2
1
0
POWER OUTPUT WATTS
I_a TOTAL
OUTPUT
2nd HARMONIC
3rd
0
5
10
15
20
R.M.S.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

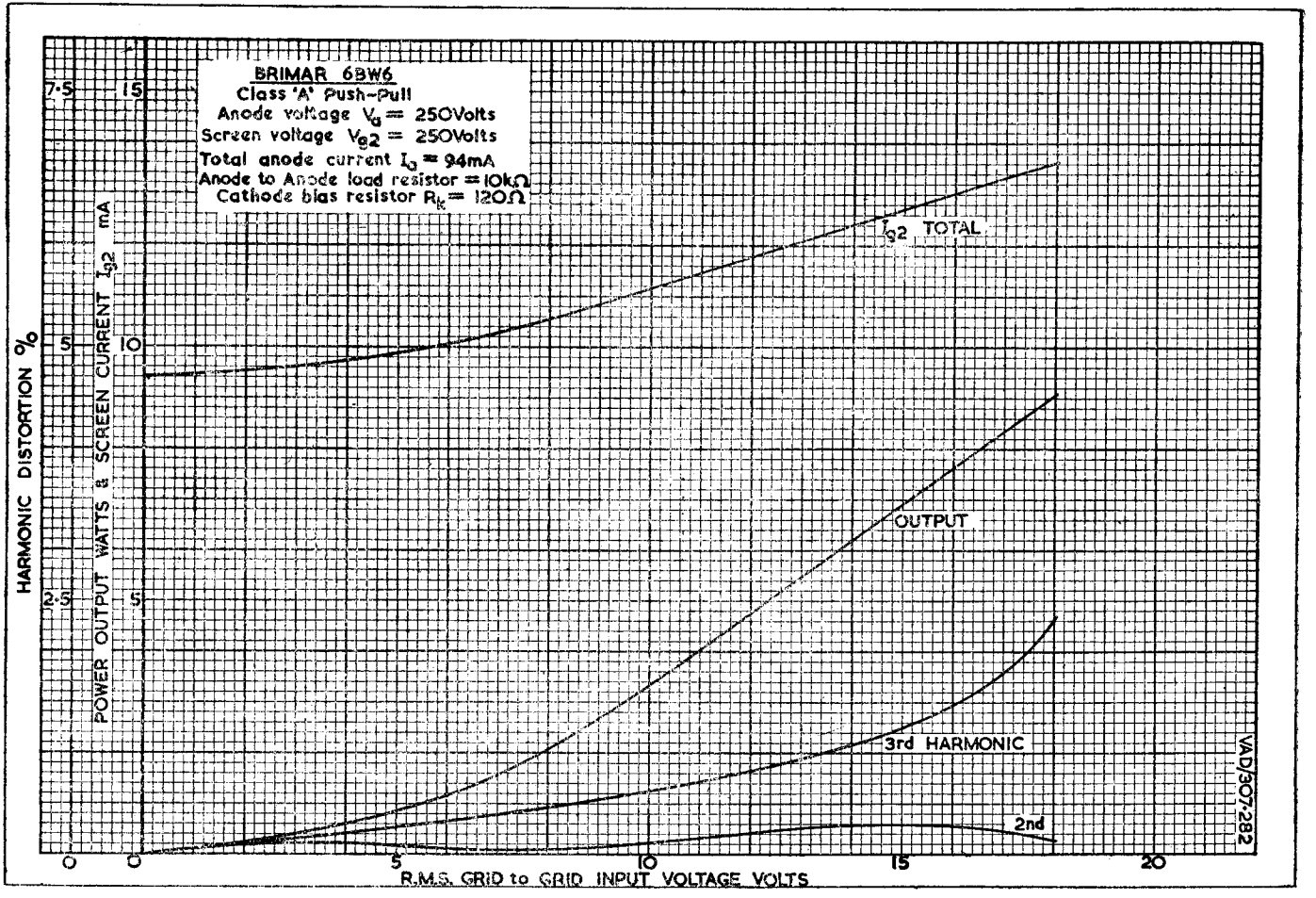

VAD/307-277
BRIMAR 6BW6
Triode connected
(g2 connected to anode)
Class 'A' Push-Pull
Anode voltage V_a = 285Volts
Anode to Anode load resistor=4·5kΩ
Cathode bias resistor R_k=240Ω
ANODE CURRENT I_a mA
85
80
75
I_a TOTAL
OUTPUT
2nd HARMONIC
3rd
HARMONIC DISTORTION %
0·5
0·25
0
POWER OUTPUT WATTS
4
3
2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

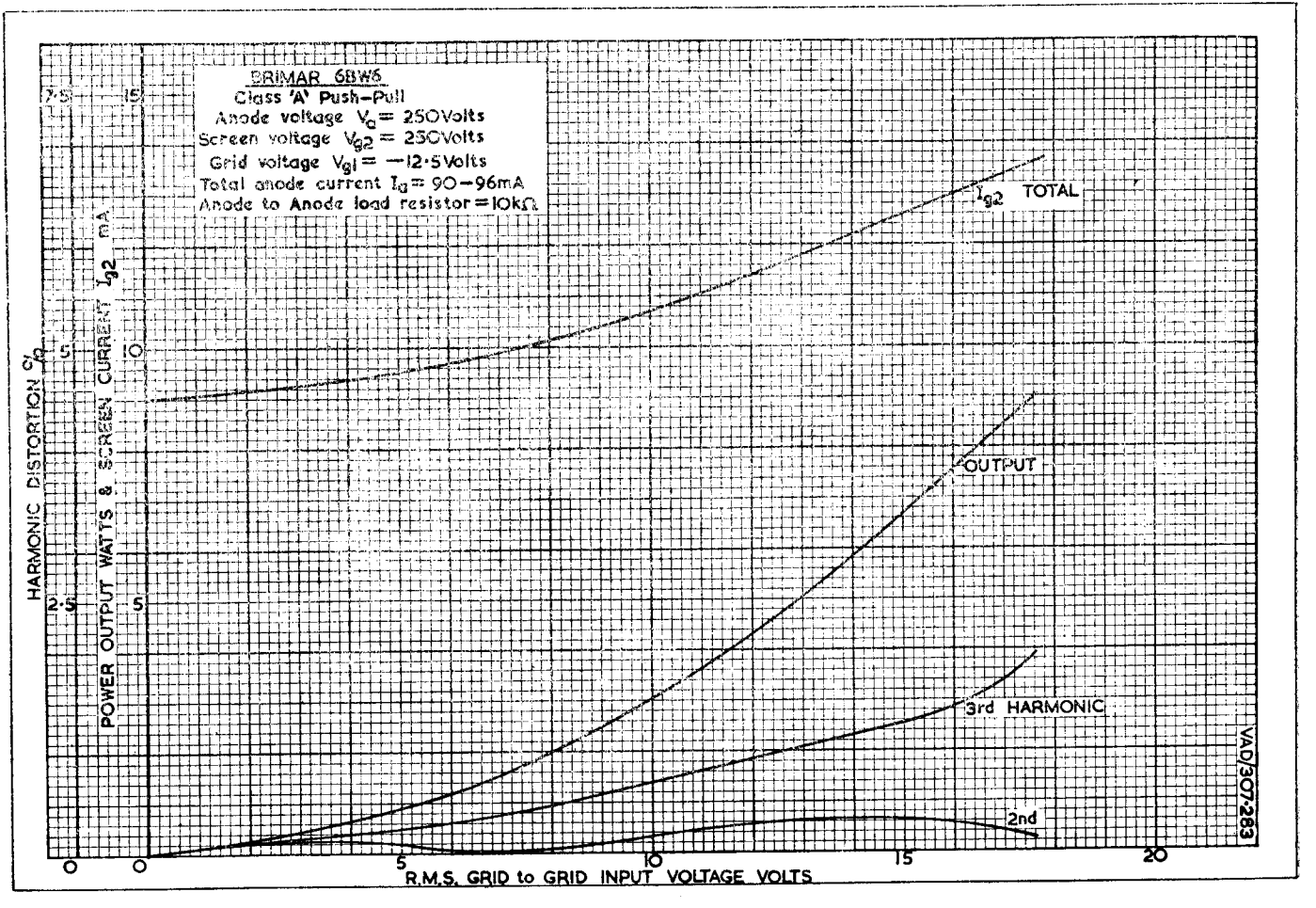

VAD/307·278
BRIMAR 6BW6
Class 'A'
Anode voltage V_a = 180Volts
Screen voltage V_{g2} = 180Volts
Anode current I_a = 29mA
Anode load resistor R_a = 5·5kΩ
Cathode bias resistor R_k = 250Ω
10
7·5
5
2·5
0
2
1·5
1
0·5
0
HARMONIC DISTORTION % & SCREEN CURRENT I_{g2} mA
POWER OUTPUT WATTS
I_{g2}
2nd HARMONIC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

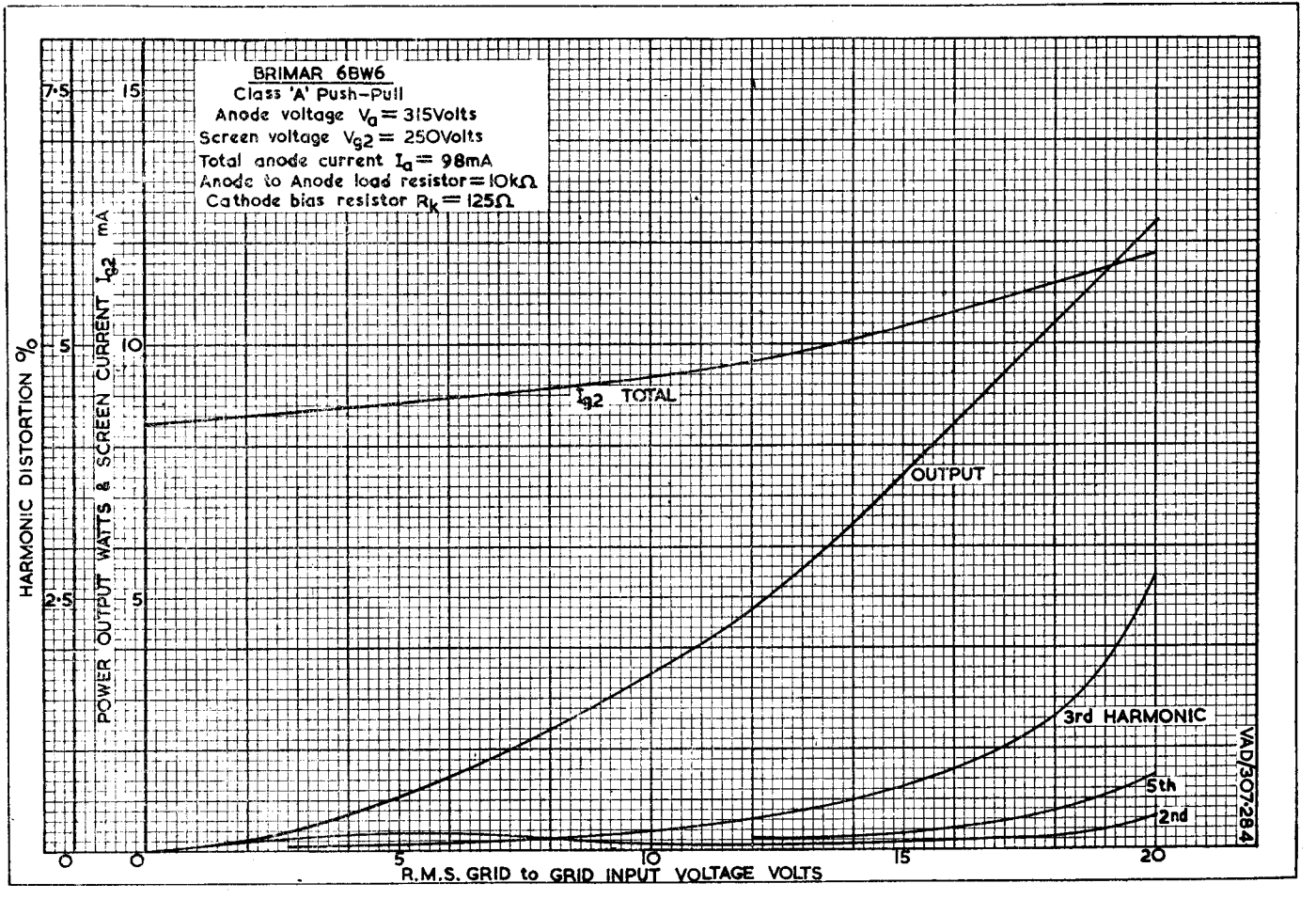

BRIMAR 6BW6
Class 'A'
Anode voltage V_a = 250Volts
Screen voltage V_{g2} = 250Volts
Anode current I_a = 47mA
Anode load resistor R_a = 5kΩ
Cathode bias resistor R_k = 240Ω
POWER OUTPUT WATTS, HARMONIC DISTORTION % & SCREEN CURRENT I_{g2} mA
7·5
5
2·5
0
I_{g2}
2nd HARMONIC
OUTPUT
3rd
2·5
5
7·5
10
R.M.S. INPUT VOLTAGE VOLTS
VAD/307.279

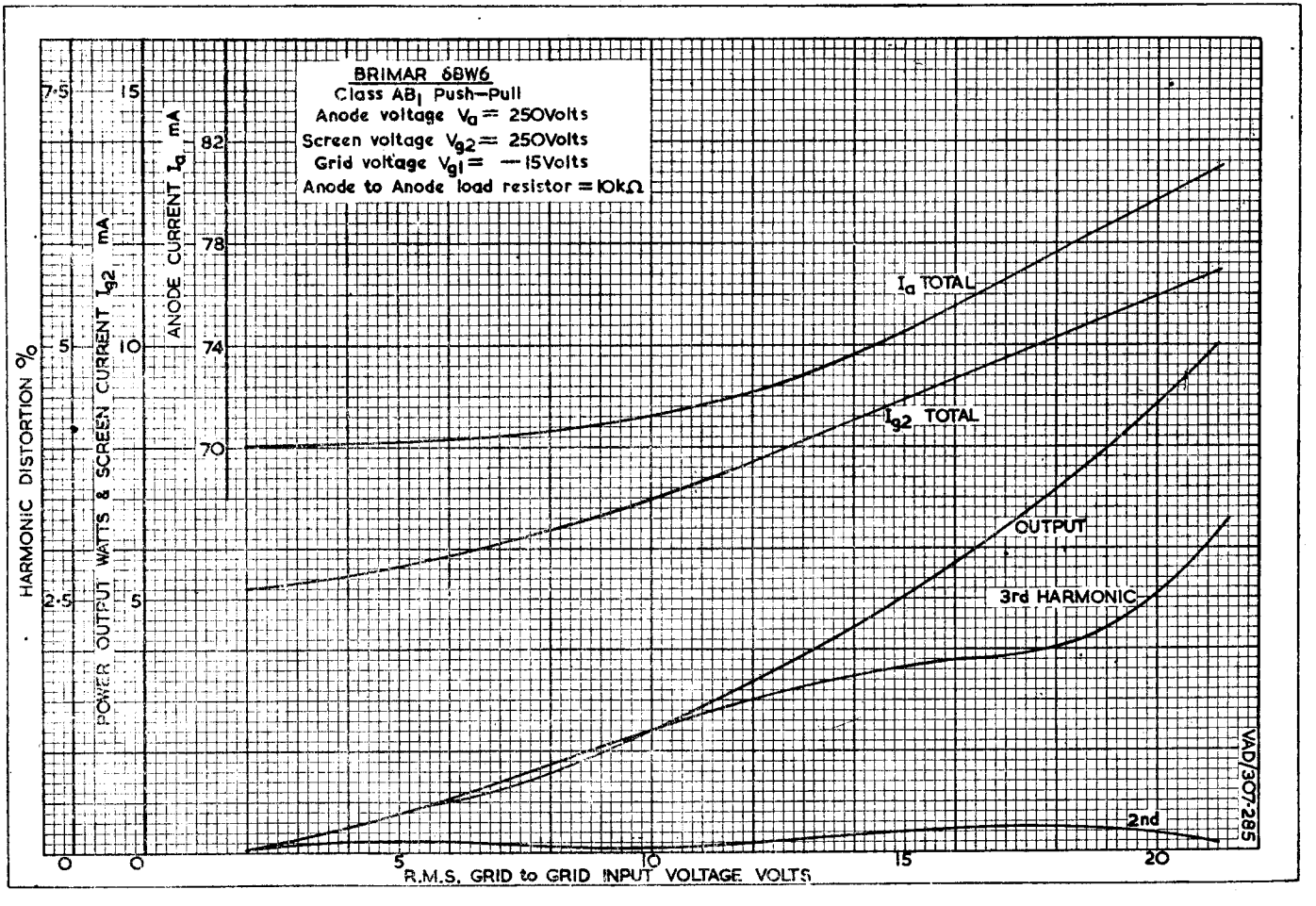

BRIMAR 6BW6
Class 'A'
Anode voltage V_a = 315Volts
Screen voltage V_{g2} = 225Volts
Anode current I_a = 34mA
Anode load resistor R_a = 8·5kΩ
Cathode bias resistor R_k = 330Ω
HARMONIC DISTORTION %
POWER OUTPUT WATTS & SCREEN CURRENT I_{g2} mA
15
7·5
10
5
5
2·5
0
0
2·5
5
7·5
10
R.M.S. INPUT VOLTAGE VOLTS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

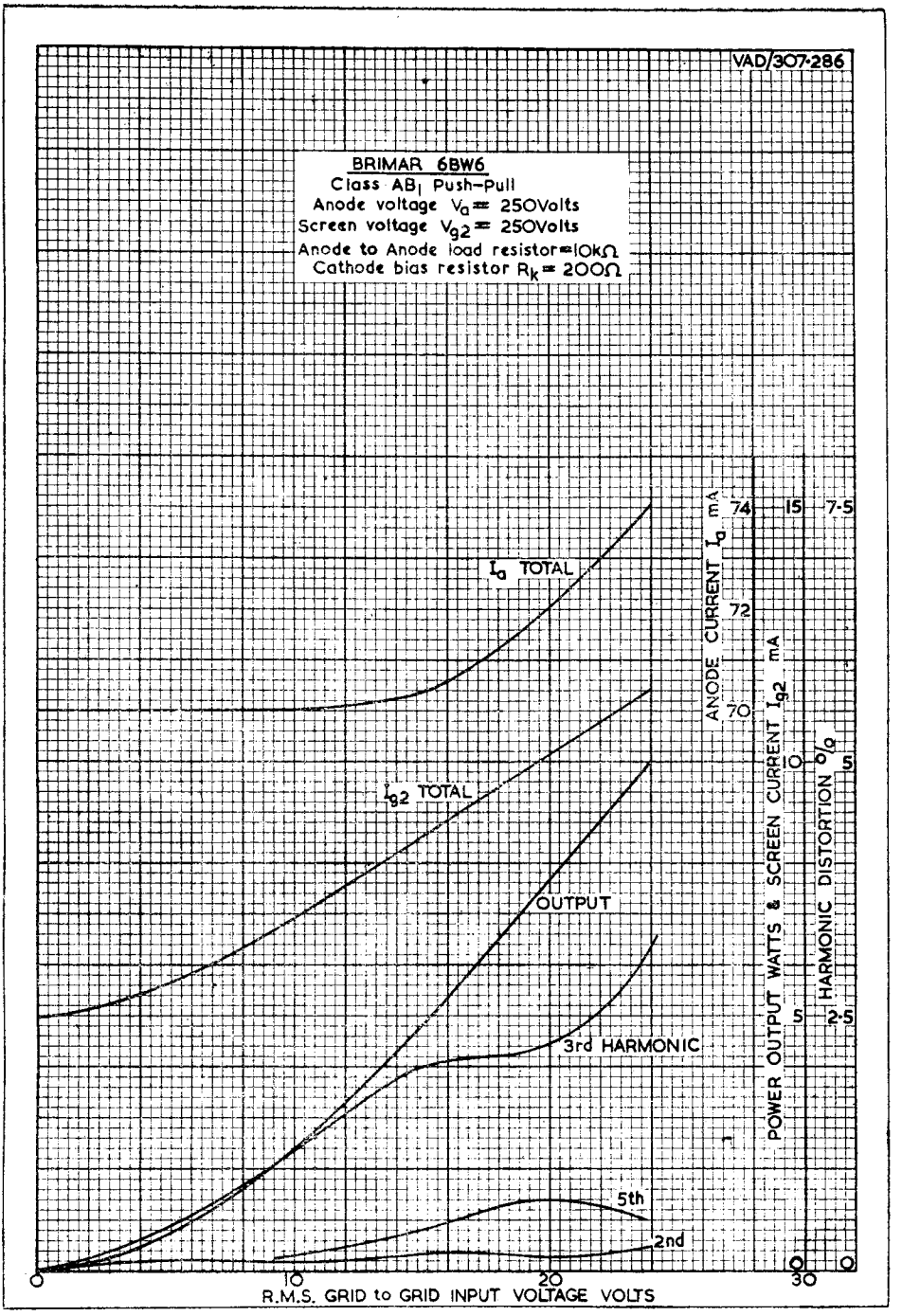

VAD/307·28I
BRIMAR 6BW6
ANODE & SCREEN CURRENTS versus
ANODE VOLTAGE
Screen voltage V_{g2} = 225 Volts
I_a ——— I_{g2} — — — — —
CONTROL GRID VOLTS V_{g1} = 0
−5
−10
−13
−15
−20
−26
−13
ANODE CURRENT I_a mA
SCREEN CURRENT I_{g2} mA
100
75
50
25
0
20
15
10
5
0
0
250
500
750
ANODE VOLTAGE VOLTS

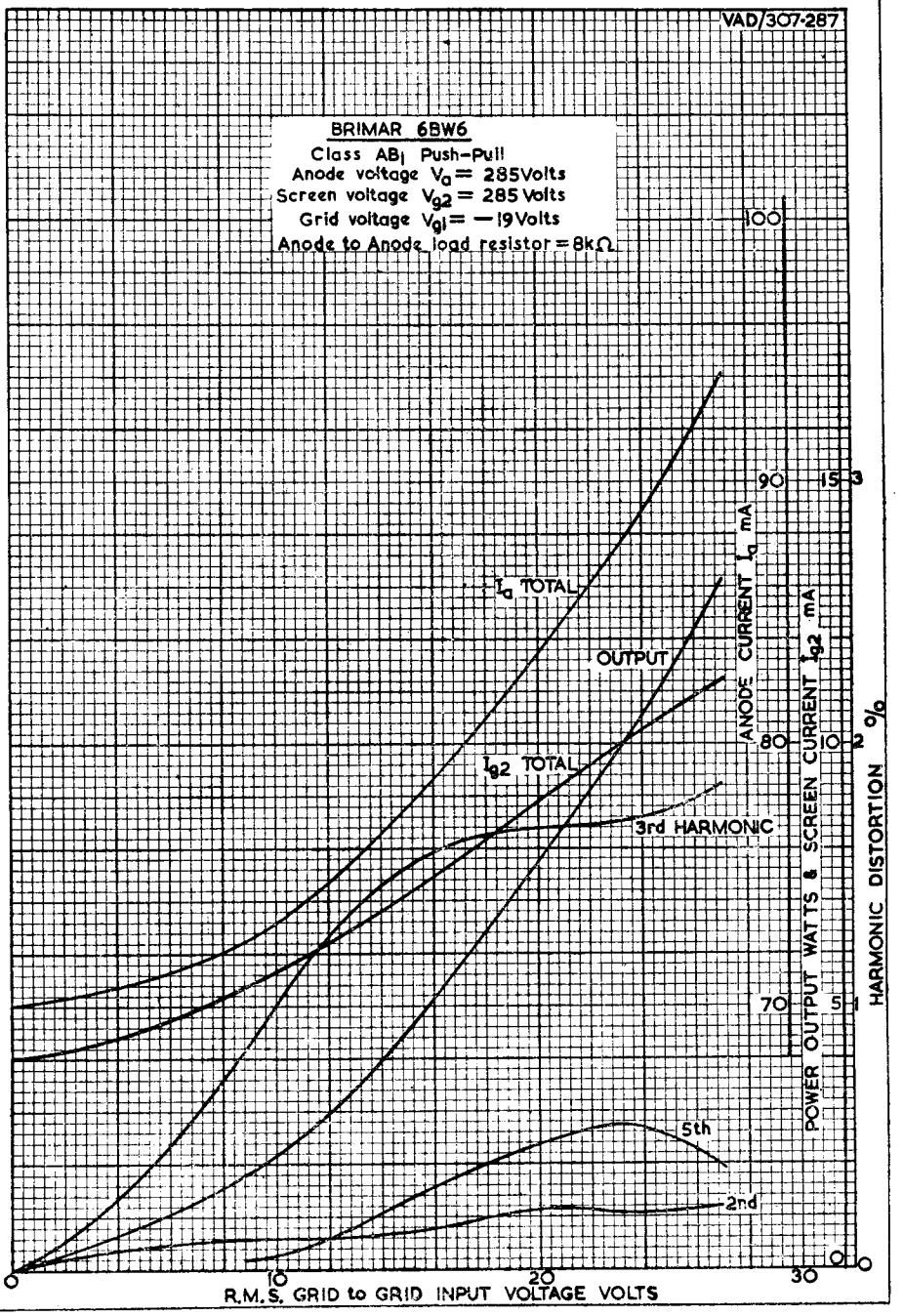

BRIMAR 6BW6
Class 'A' Push-Pull
Anode voltage V_a = 250Volts
Screen voltage V_{g2} = 250Volts
Total anode current I_a = 94mA
Anode to Anode load resistor = 10kΩ
Cathode bias resistor R_k = 120Ω
HARMONIC DISTORTION %
POWER OUTPUT WATTS & SCREEN CURRENT I_{g2} mA
7·5
15
5
10
2·5
5
0
0
5
10
15
20
R.M.S. GRID to GRID INPUT VOLTAGE VOLTS
I_{g2} TOTAL
OUTPUT
3rd HARMONIC
2nd
VAD/307-282

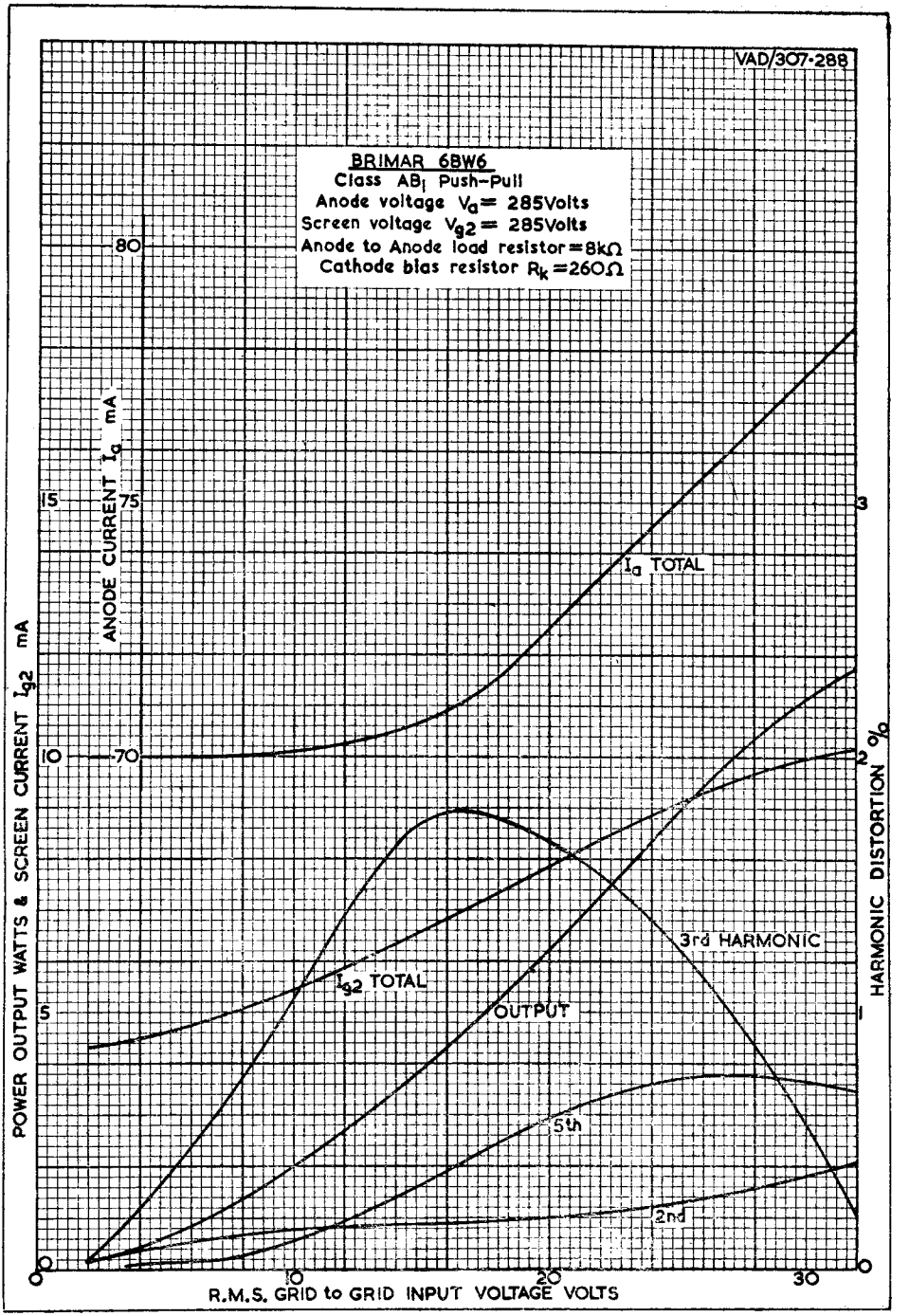

PRIMAR 6BW6
Class 'A' Push-Pull
Anode voltage V_a = 250Volts
Screen voltage V_{g2} = 250Volts
Grid voltage V_{g1} = −12·5Volts
Total anode current I_a = 90−96mA
Anode to Anode load resistor = 10kΩ
I_{g2} TOTAL
OUTPUT
3rd HARMONIC
2nd
HARMONIC DISTORTION %
POWER OUTPUT WATTS & SCREEN CURRENT I_{g2} mA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

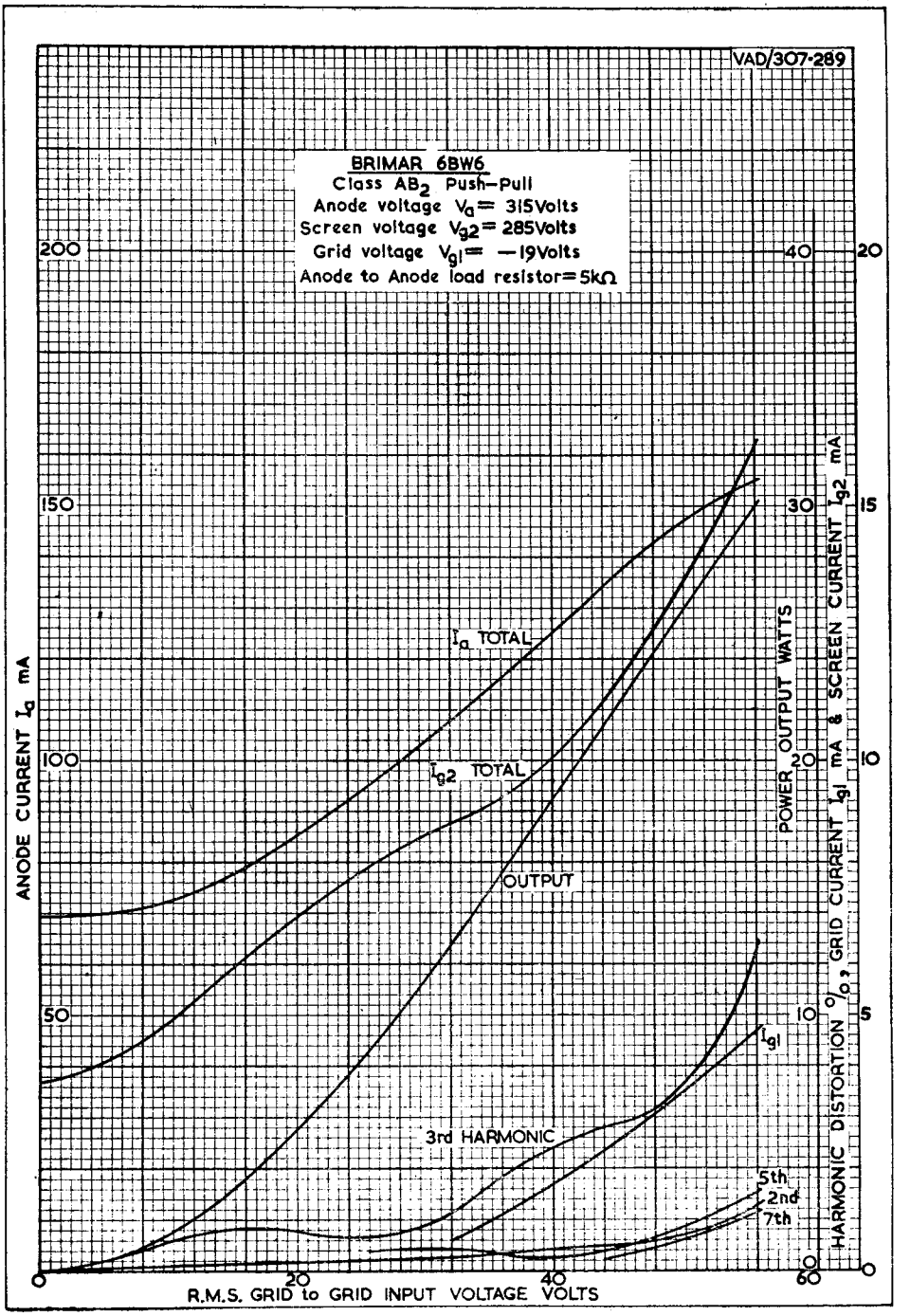

BRIMAR 6BW6
Class 'A' Push-Pull
Anode voltage V_a = 315Volts
Screen voltage V_{g2} = 250Volts
Total anode current I_a = 98mA
Anode to Anode load resistor = 10kΩ
Cathode bias resistor R_k = 125Ω
HARMONIC DISTORTION %
POWER OUTPUT WATTS & SCREEN CURRENT I_{g2} mA
7·5
2·5
15
10
5
0
I_{g2} TOTAL
OUTPUT
3rd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

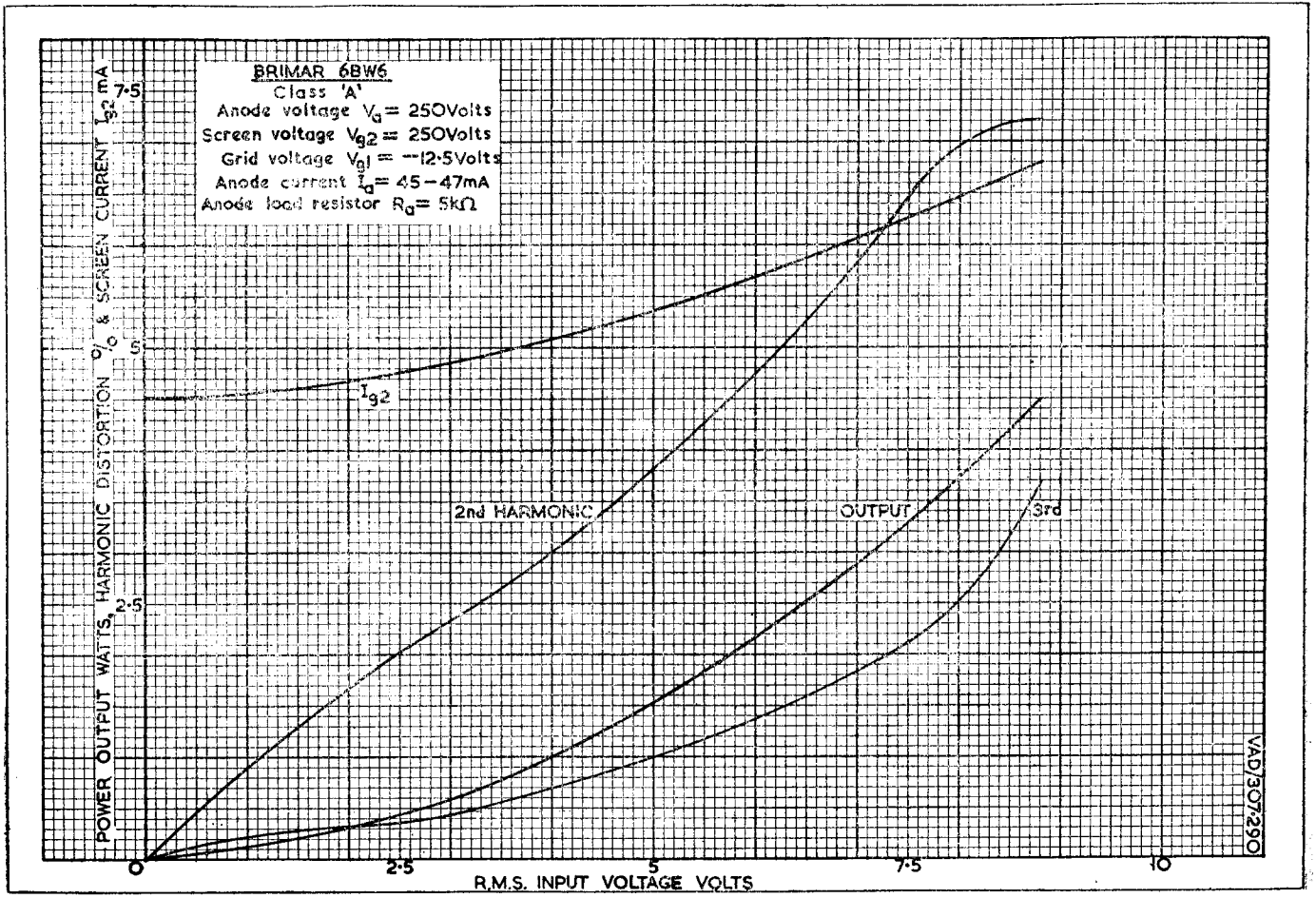

BRIMAR 6BW6
Class AB1 Push-Pull
Anode voltage Va = 250Volts
Screen voltage Vg2 = 250Volts
Grid voltage Vg1 = —15Volts
Anode to Anode load resistor = 10kΩ
HARMONIC DISTORTION %
POWER OUTPUT WATTS & SCREEN CURRENT Ig2 mA
ANODE CURRENT Ia mA
Ia TOTAL
Ig2 TOTAL
OUTPUT
3rd HARMONIC
2nd
R.M.S. GRID to GRID INPUT VOLTAGE VOLTS
VAD/307-285

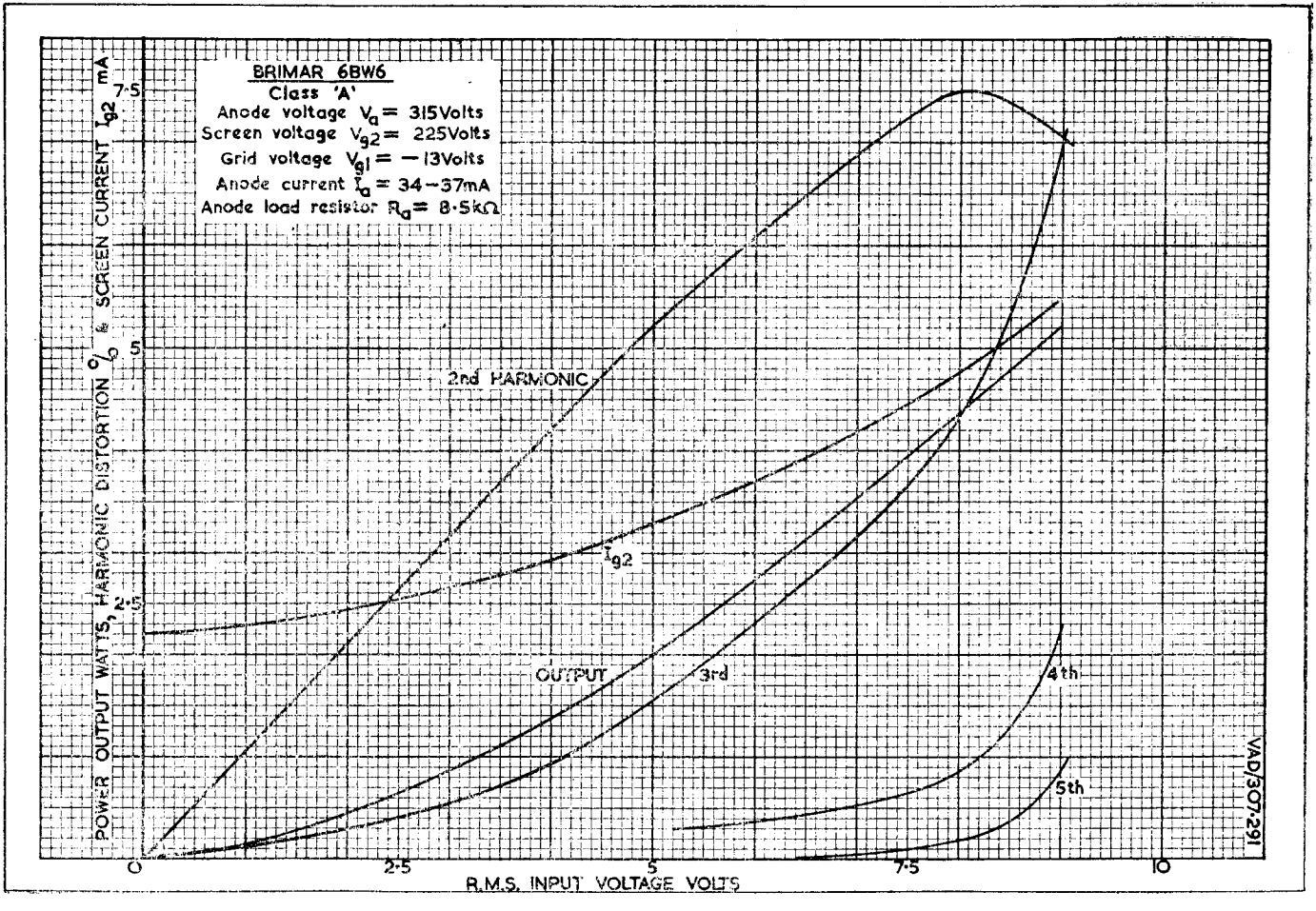

VAD/307-286
BRIMAR 6BW6
Class AB1 Push-Pull
Anode voltage Va = 250Volts
Screen voltage Vg2 = 250Volts
Anode to Anode load resistor=10kΩ
Cathode bias resistor Rk = 200Ω
Ia TOTAL
Ig2 TOTAL
OUTPUT
3rd HARMONIC
5th
2nd
ANODE CURRENT Ia mA
74
72
70
15
7·5
POWER OUTPUT WATTS & SCREEN CURRENT Ig2 mA
10
5
HARMONIC DISTORTION %
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 = 285 Volts
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
ANODE CURRENT Ia mA
POWER OUTPUT WATTS & SCREEN CURRENT Ig2 mA
HARMONIC DISTORTION %
100
90
80
70
15
10
5
3
2
1
0
10
20
30
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
POWER OUTPUT WATTS & SCREEN CURRENT Ig2 mA
ANODE CURRENT Ia mA
HARMONIC DISTORTION %
R.M.S. GRID to GRID INPUT VOLTAGE VOLTS
Ia TOTAL
Ig2 TOTAL
OUTPUT
3rd HARMONIC
5th
2nd
80
75
70
15
10
5
0
3
2
1
0
10
20
30


VAD/307-289
BRIMAR 6BW6
Class AB2 Push-Pull
Anode voltage Va = 315Volts
Screen voltage Vg2 = 285Volts
Grid voltage Vg1 = −19Volts
Anode to Anode load resistor=5kΩ
ANODE CURRENT Ia mA
200
150
100
50
0
Ia TOTAL
Ig2 TOTAL
OUTPUT
3rd HARMONIC
5th
2nd
7th
Ig1
40
30
20
10
0
POWER OUTPUT WATTS
SCREEN CURRENT Ig2 mA
20
15
10
5
0
GRID CURRENT Ig1 mA
HARMONIC DISTORTION %
0
20
40
60
R.M.S. GRID to GRID INPUT VOLTAGE VOLTS


BRIMAR 6BW6
Class 'A'
Anode voltage V_a = 250Volts
Screen voltage V_{g2} = 250Volts
Grid voltage V_{g1} = −12·5Volts
Anode current I_a = 45−47mA
Anode load resistor R_a = 5kΩ
POWER OUTPUT WATTS, HARMONIC DISTORTION % & SCREEN CURRENT I_{g2} mA
7·5
5
2·5
0
I_{g2}
2nd HARMONIC
OUTPUT
3rd
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
POWER OUTPUT WATTS, HARMONIC DISTORTION % & SCREEN CURRENT I_{g2} mA
7·5
5
2·5
0
2nd HARMONIC
I_{g2}
OUTPUT
3rd
4th
5th
0
2·5
5
7·5
10
R.M.S. INPUT VOLTAGE VOLTS
VAD/307.291

BRIMAR

RECEIVING VALVE

6CD6G

APPLICATION REPORT VAD/507.9

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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 g1
Pin 6 No Pin NP
Pin 7 Heater h
Pin 8 Screen Grid g2
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:

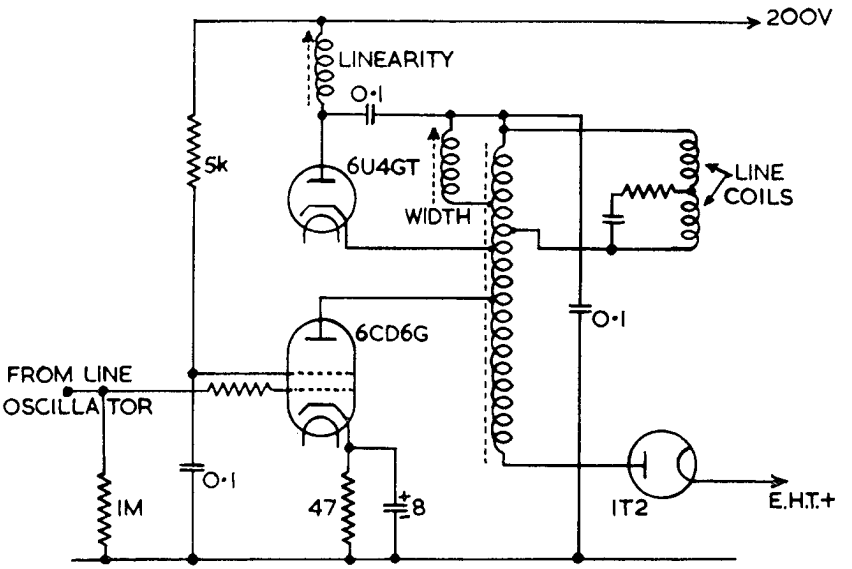
Anode Voltage	110	200	volts
Screen Voltage	110	110	volts
Grid Voltage	—11·7	—14	volts
Cathode Bias Resistor	56	90	ohms
Anode Current (no signal)	200	160	mA
Screen Current (no signal)	13·2	4·8	mA
Screen Current (max. signal)	16·3	11·6	mA
Peak Grid to Grid Input Voltage	22·6	28	volts
Anode to Anode Load	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.

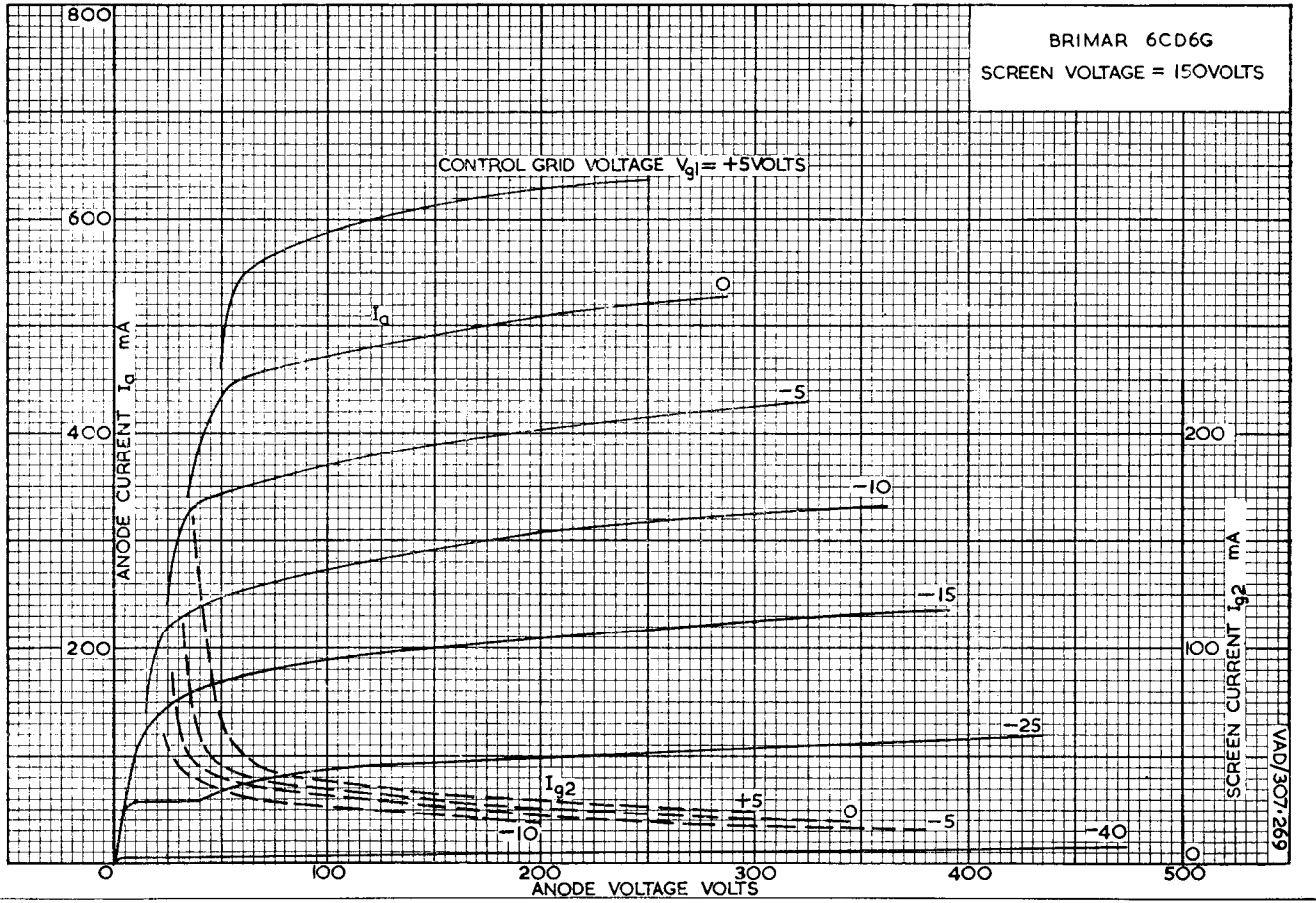
Because its primary application is in television where Class 'A' working is not normal, greater emphasis is placed on operational testing in typical circuitry than on normal static tests under Class 'A' conditions. Consequently when the 6CD6G is used as an audio amplifier, rather wider variations in 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.

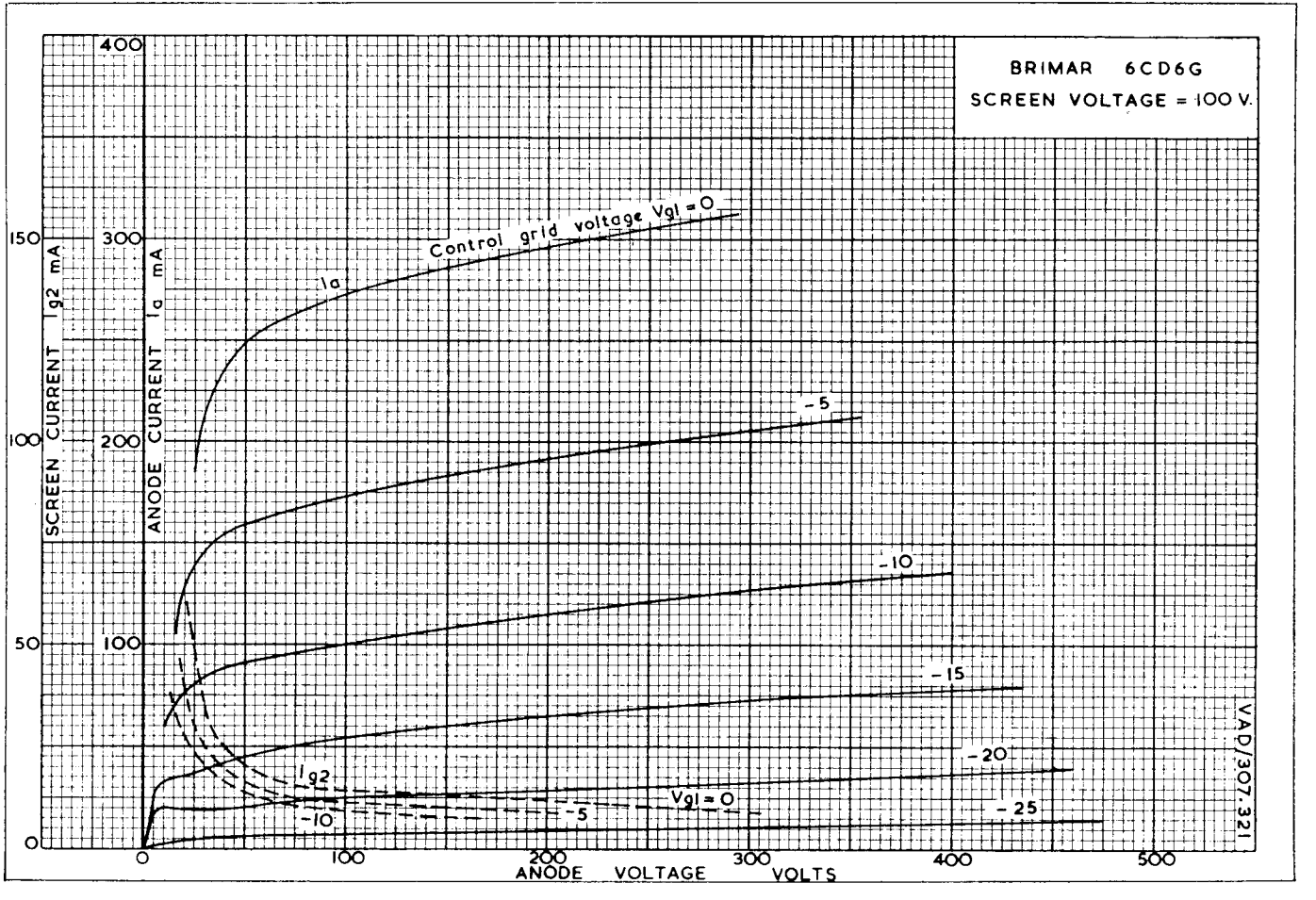
Nevertheless, there may be occasions when it is desired to take advantage of the special characteristics of this valve, so operating data and curves for AF amplifier service are included in this report.

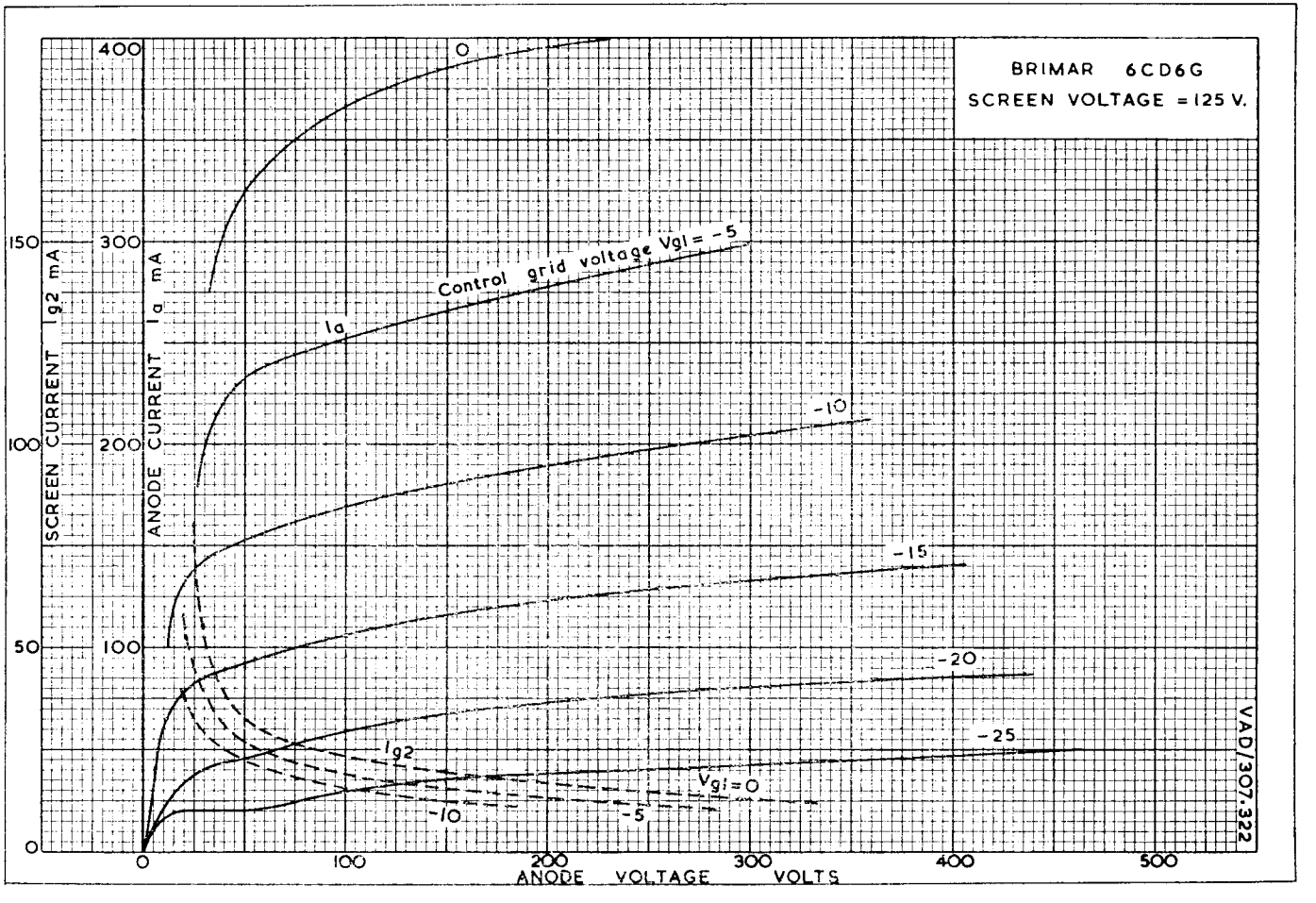
4.3 Series Stabiliser Valve in Regulated Power Supply: The 6CD6G is suitable for this application connected as a triode. Although the anode dissipation is rather low for this work (16·5 watts), the lower volt drop somewhat outweighs this disadvantage. Care must be taken that the anode dissipation is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

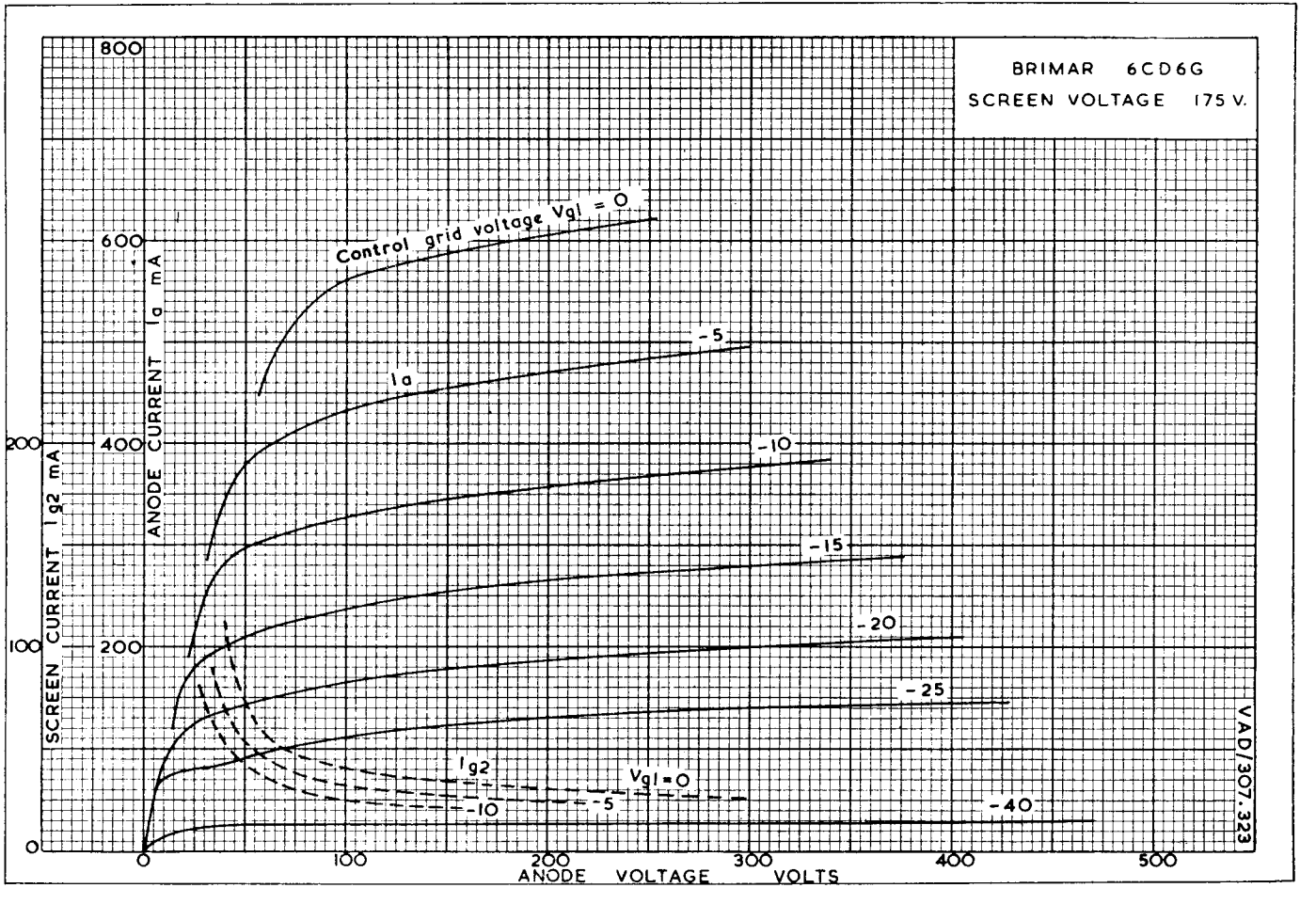


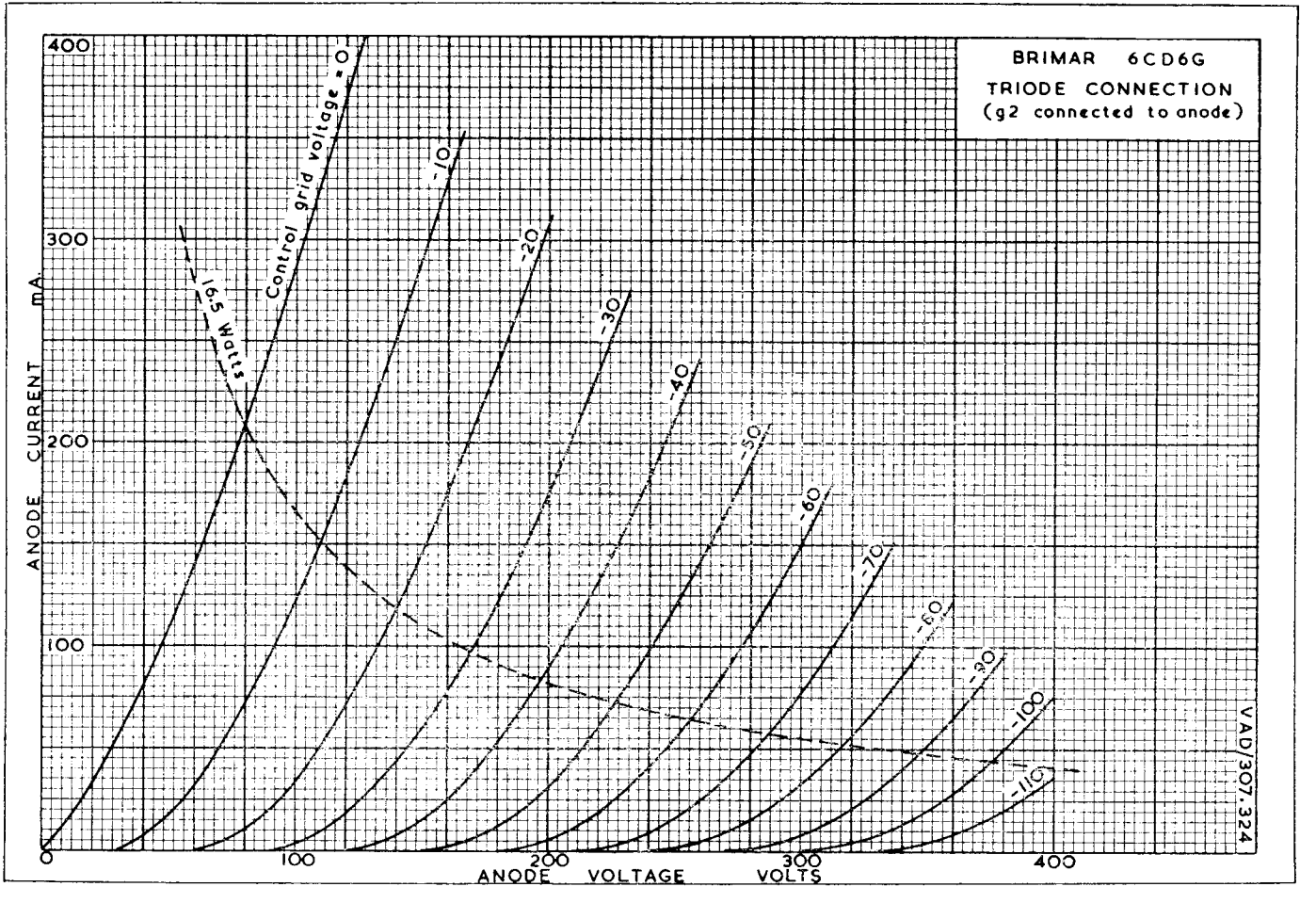
TELEVISION LINE OUTPUT CIRCUIT

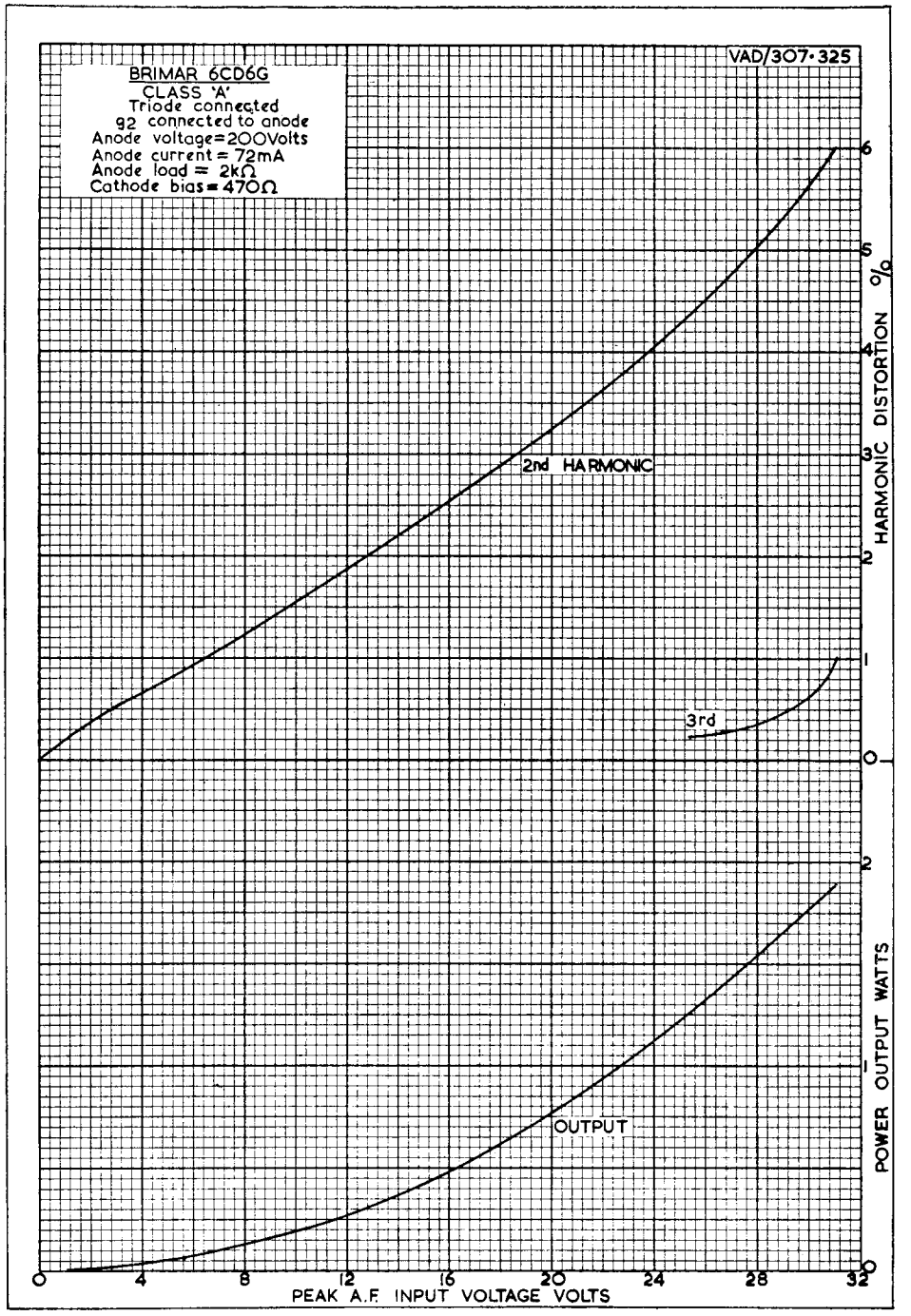

BRIMAR 6CD6G
SCREEN VOLTAGE = 150VOLTS
CONTROL GRID VOLTAGE V_{g1} = +5VOLTS
0
-5
-10
-15
-25
-40
I_a
I_{g2}
+5
0
-5
-10
800
600
400
200
0
100
200
300
400
500
ANODE CURRENT I_a mA
SCREEN CURRENT I_{g2} mA
ANODE VOLTAGE VOLTS
VA0/307-269

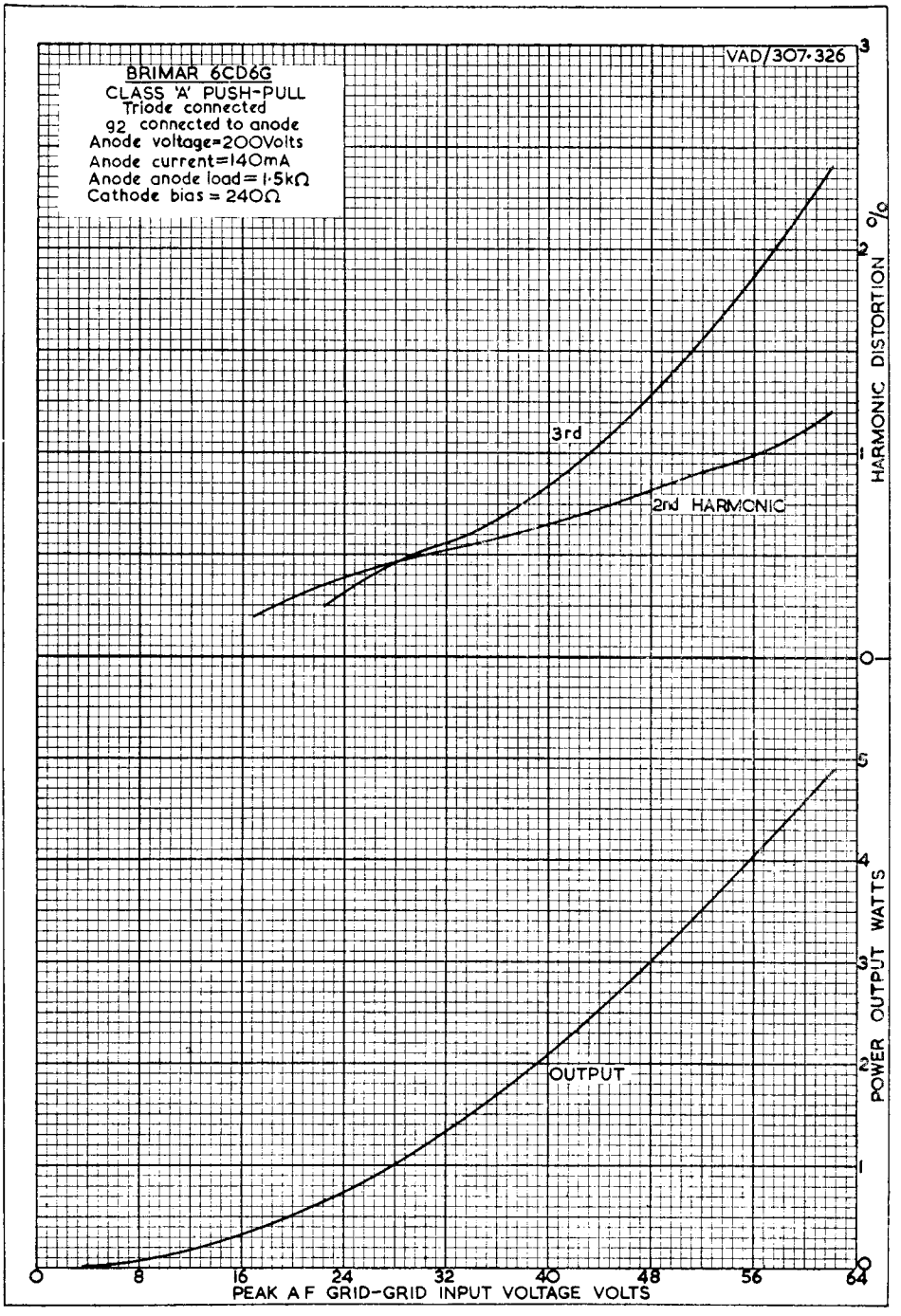

BRIMAR 6CD6G
SCREEN VOLTAGE = 100 V.
SCREEN CURRENT Ig2 mA
ANODE CURRENT Ia mA
Control grid voltage Vg1 = 0
Ia
-5
-10
-15
-20
-25
Ig2
Vg1 = 0
-5
-10
ANODE VOLTAGE VOLTS
VAD/307.321

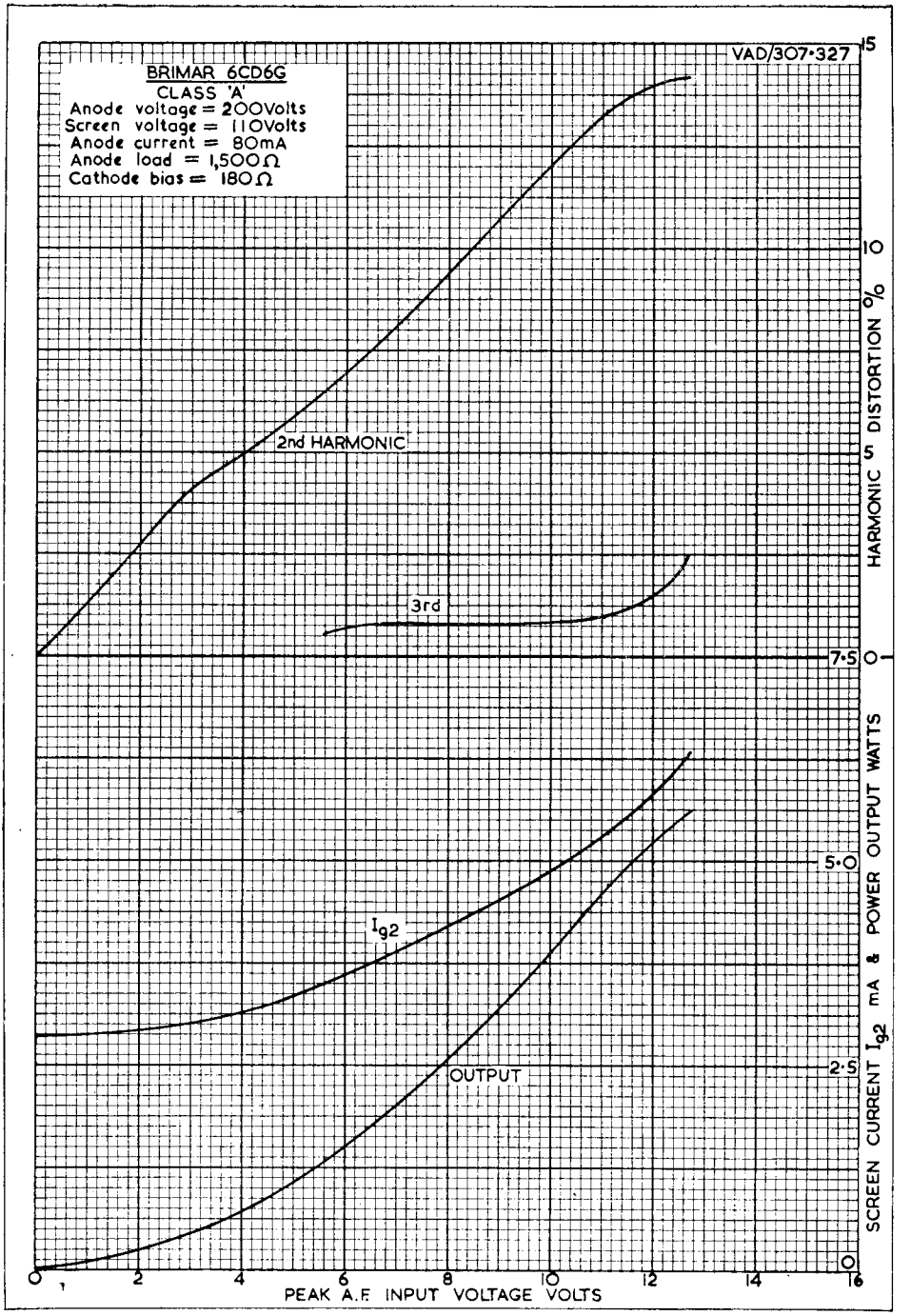

BRIMAR 6CD6G
SCREEN VOLTAGE = 125 V.
SCREEN CURRENT Ig2 mA
ANODE CURRENT Ia mA
ANODE VOLTAGE VOLTS
Control grid voltage Vg1 = -5
Ia
Ig2
Vg1 = 0
0
-5
-10
-15
-20
-25
VAD/307.322

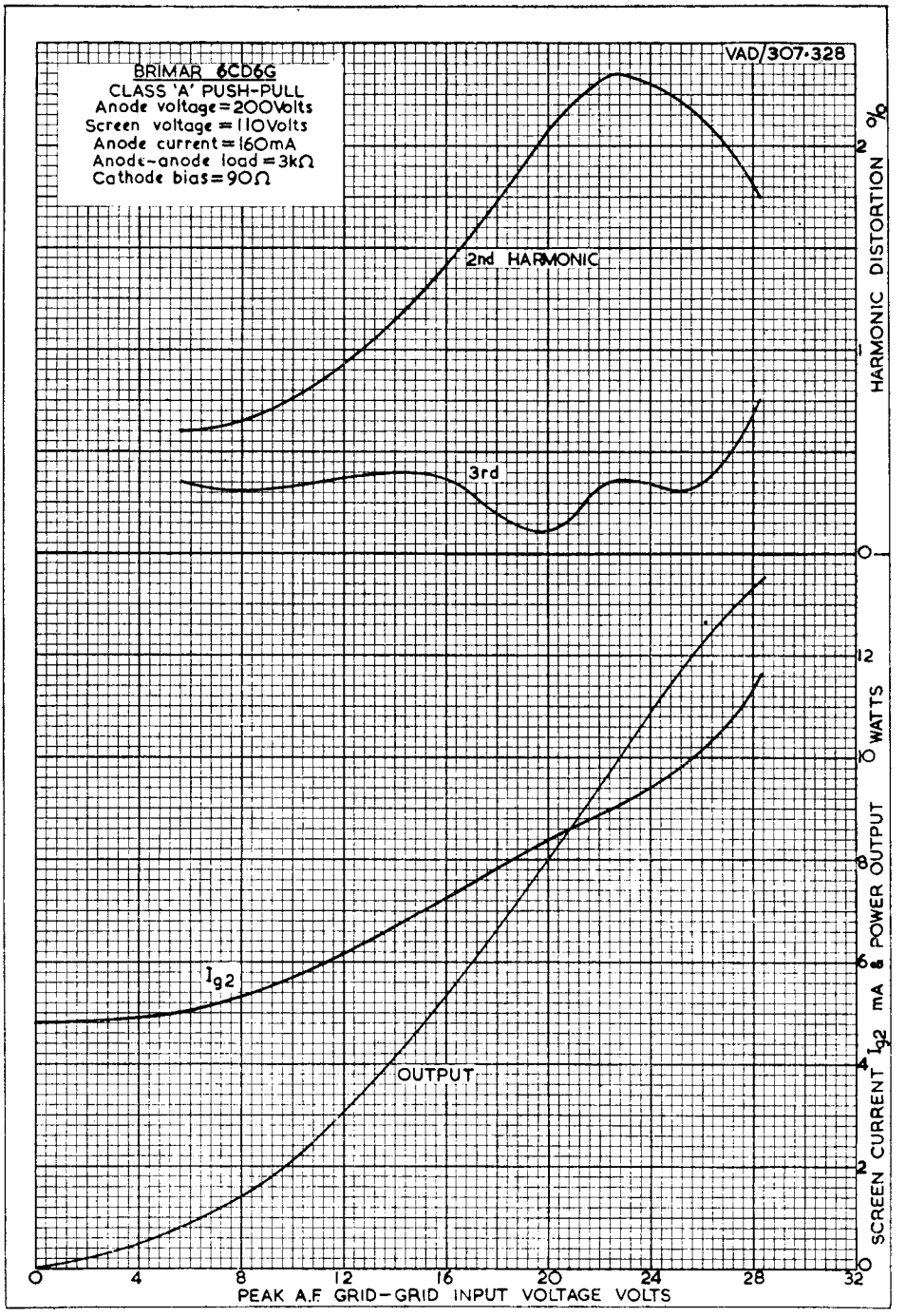

BRIMAR 6CD6G
SCREEN VOLTAGE 175 V.
Control grid voltage Vg1 = 0
-5
-10
-15
-20
-25
-40
Ia
Ig2
Vg1=0
-10
-5
ANODE CURRENT Ia mA
SCREEN CURRENT Ig2 mA
ANODE VOLTAGE VOLTS
0
100
200
300
400
500
800
600
400
200
200
100
0
VAD/307.323

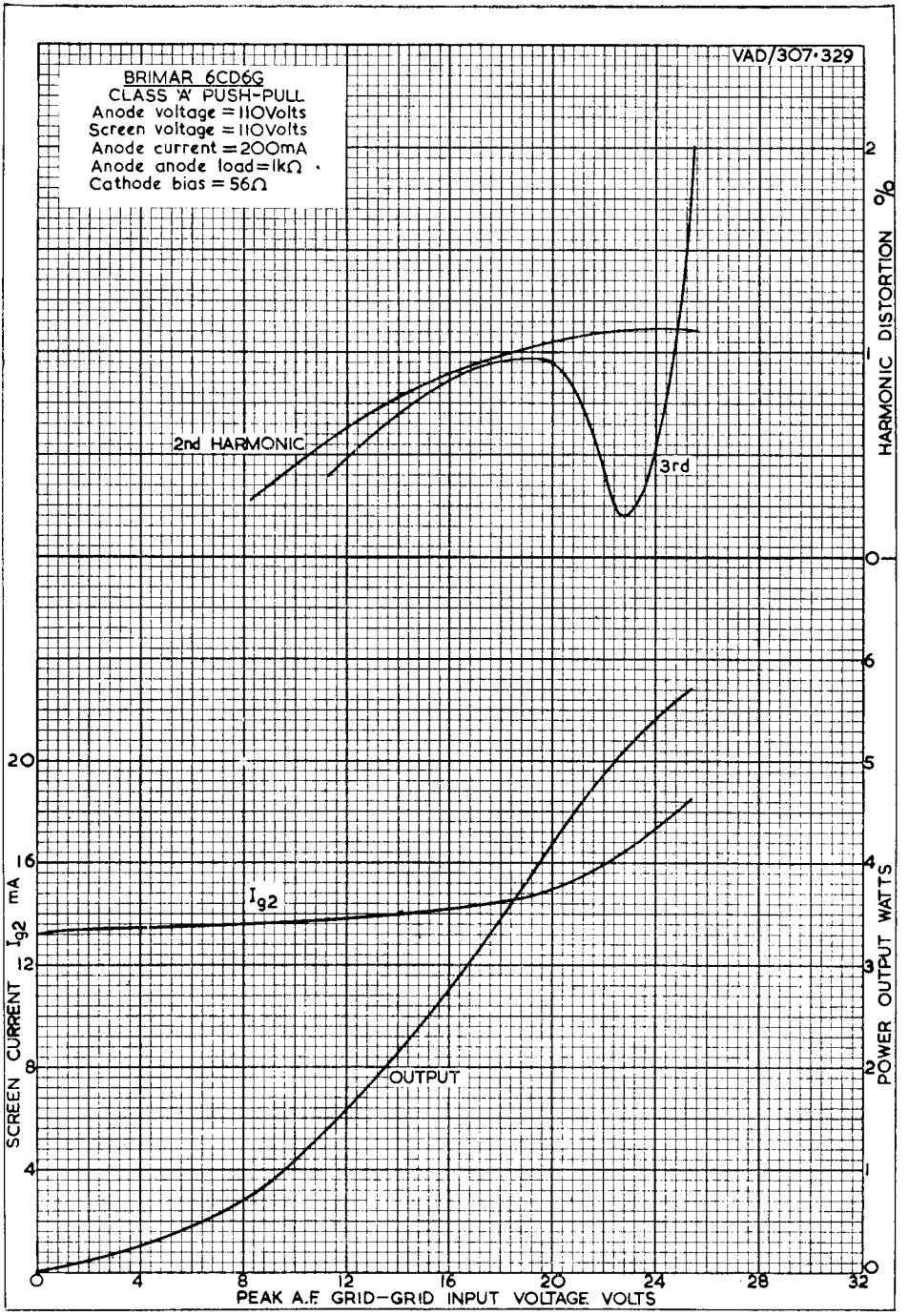

BRIMAR 6CD6G
TRIODE CONNECTION
(g2 connected to anode)
ANODE CURRENT mA.
400
300
200
100
0
100
200
300
400
ANODE VOLTAGE VOLTS
Control grid voltage = 0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
16.5 Watts
VAD/307.324


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
HARMONIC DISTORTION %
OUTPUT
POWER OUTPUT WATTS
PEAK A.F. INPUT VOLTAGE VOLTS
0
4
8
12
16
20
24
28
32
1
2
3
5
6


VAD/307·326
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
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
OUTPUT
I_{g2}
HARMONIC DISTORTION %
SCREEN CURRENT I_{g2} mA & POWER OUTPUT WATTS
PEAK A.F. INPUT VOLTAGE VOLTS
0
2
4
6
8
10
12
14
16
5
10
5
7·5
0
5·0
2·5
0


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


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
I_{g2}
OUTPUT
HARMONIC DISTORTION %
POWER OUTPUT WATTS
SCREEN CURRENT I_{g2} mA
PEAK A.F. GRID-GRID INPUT VOLTAGE VOLTS
0
4
8
12
16
20
24
28
32
1
2
3
5
6
20
16
12

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 g1
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 g2
Pin 9 Suppressor Grid g3

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:

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

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

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

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:

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

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

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

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.

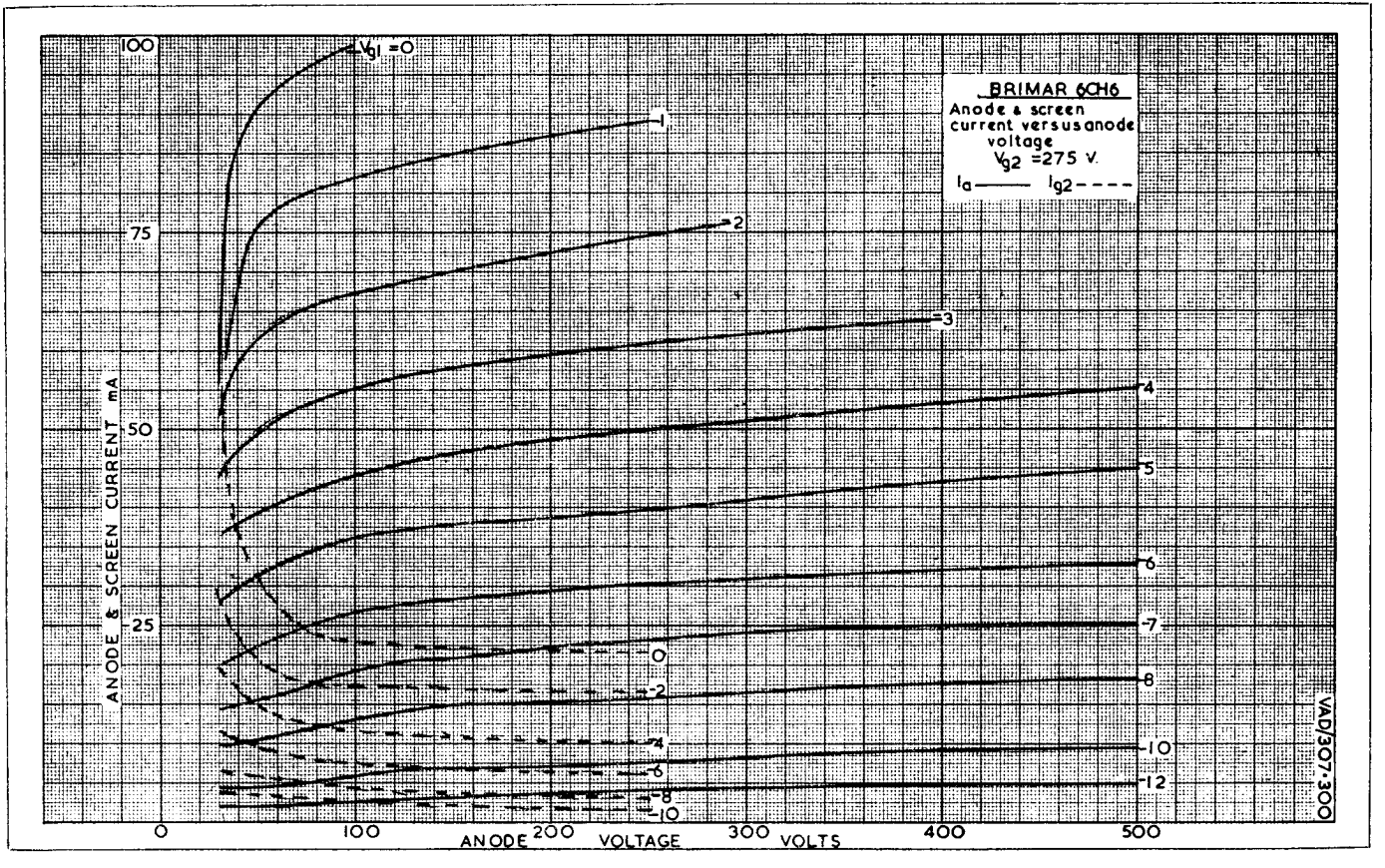
Cathode compensation gives a better low frequency response than anode compensation due to the constant degeneration at low frequencies. The cathode by-pass condenser used with anode compensation, however large, cannot provide effective decoupling at frequencies below 100 c/s.

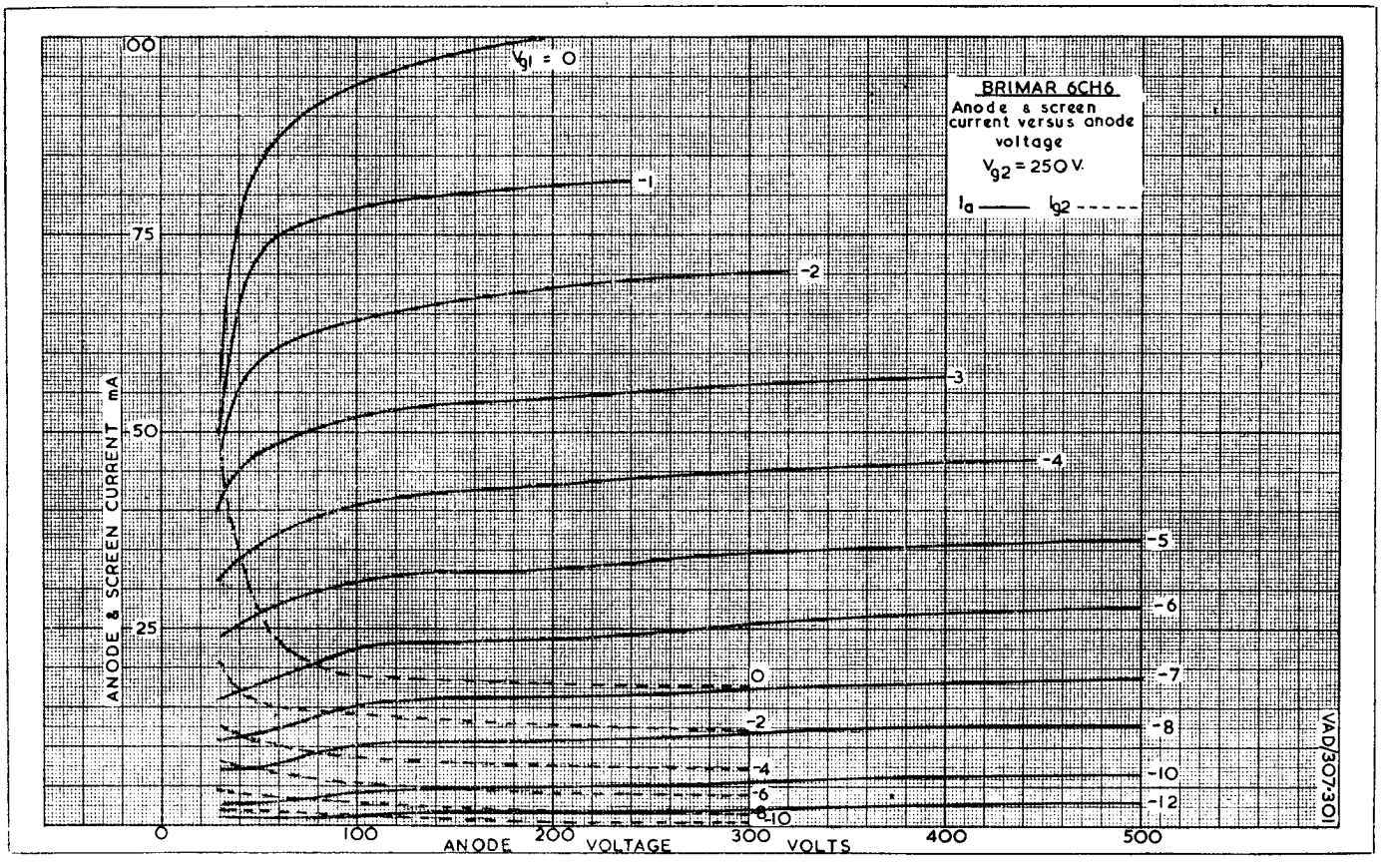
As a result of the degeneration the cathode compensated amplifier suffers from the disadvantage of relatively low gain. The available output voltage is the same as for anode compensation, but a larger input voltage is required to generate it.

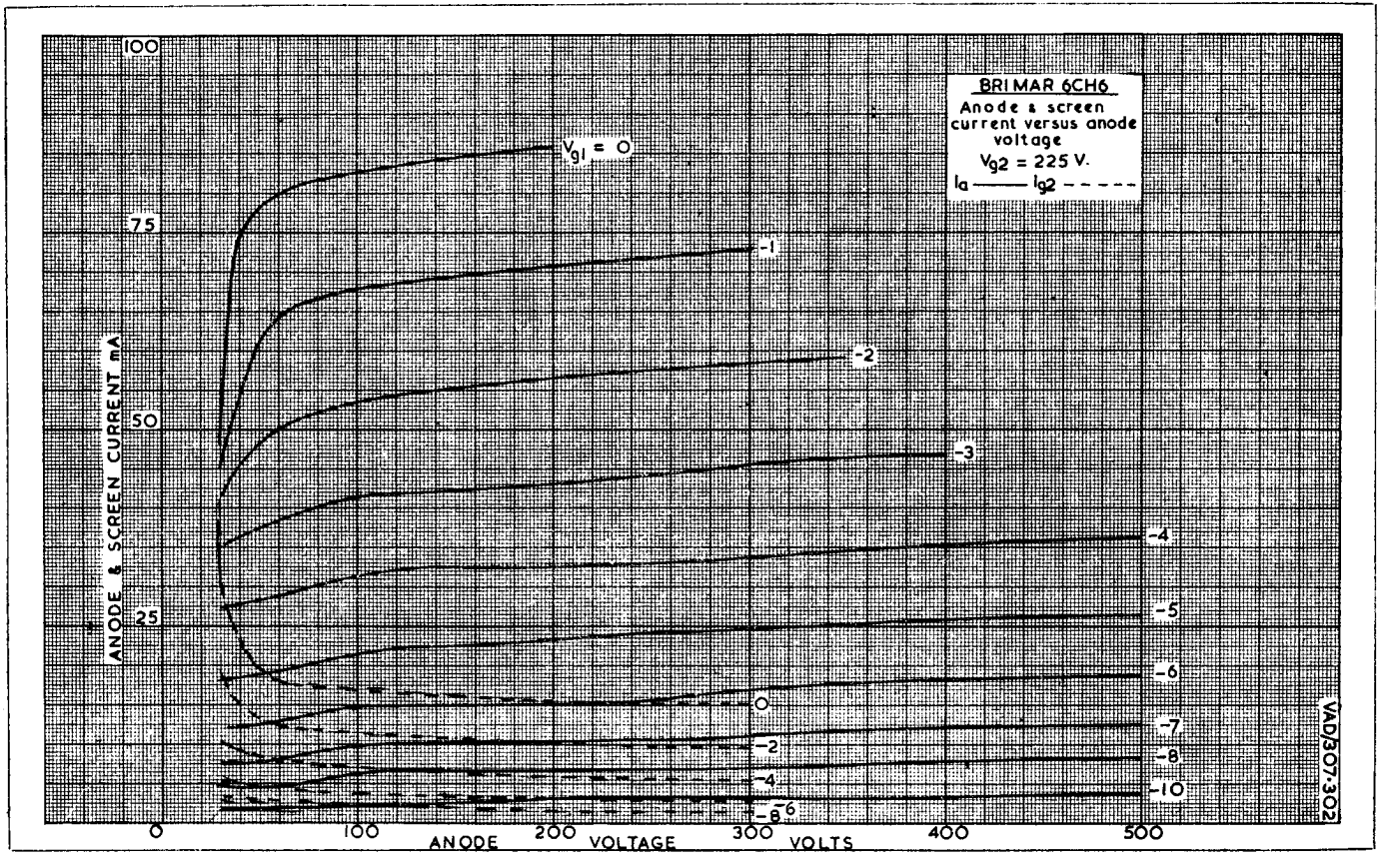
7.0 Cathode Follower: Due to its high slope the 6CH6 is very suitable for a cathode follower stage where a low output impedance is required. Triode connected, the output impedance varies between 60 and 70 ohms depending on the value of cathode resistor employed. With a 250 volt HT supply the cathode 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.

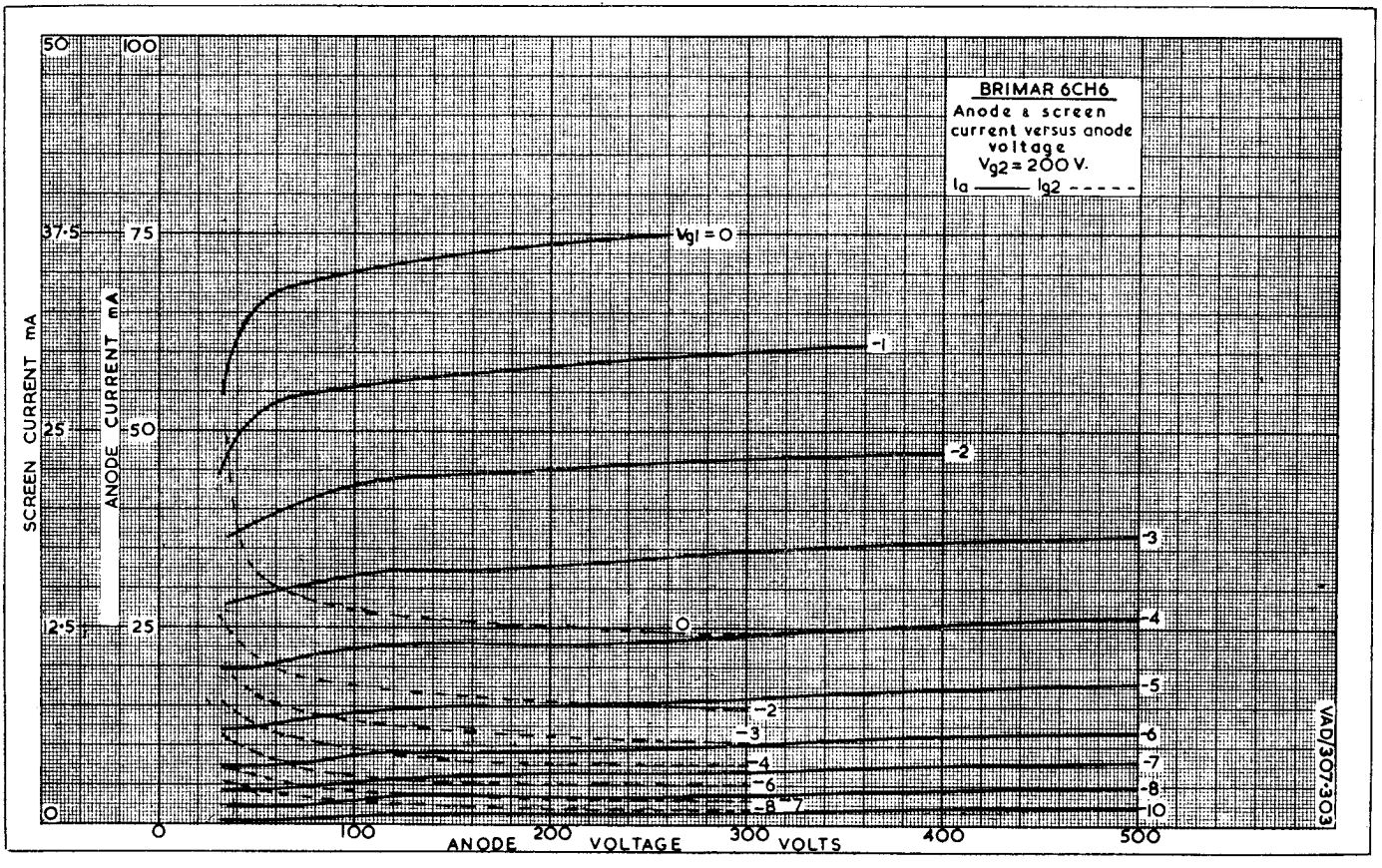
8.0 Positive Grid Characteristics: The Curve No. 307·317 shows the characteristics of the 6CH6 with the control grid positive. These curves are useful if the valve is to be used as a pulse modulator or similar application where the control grid is driven positive, as it enables peak anode, screen and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

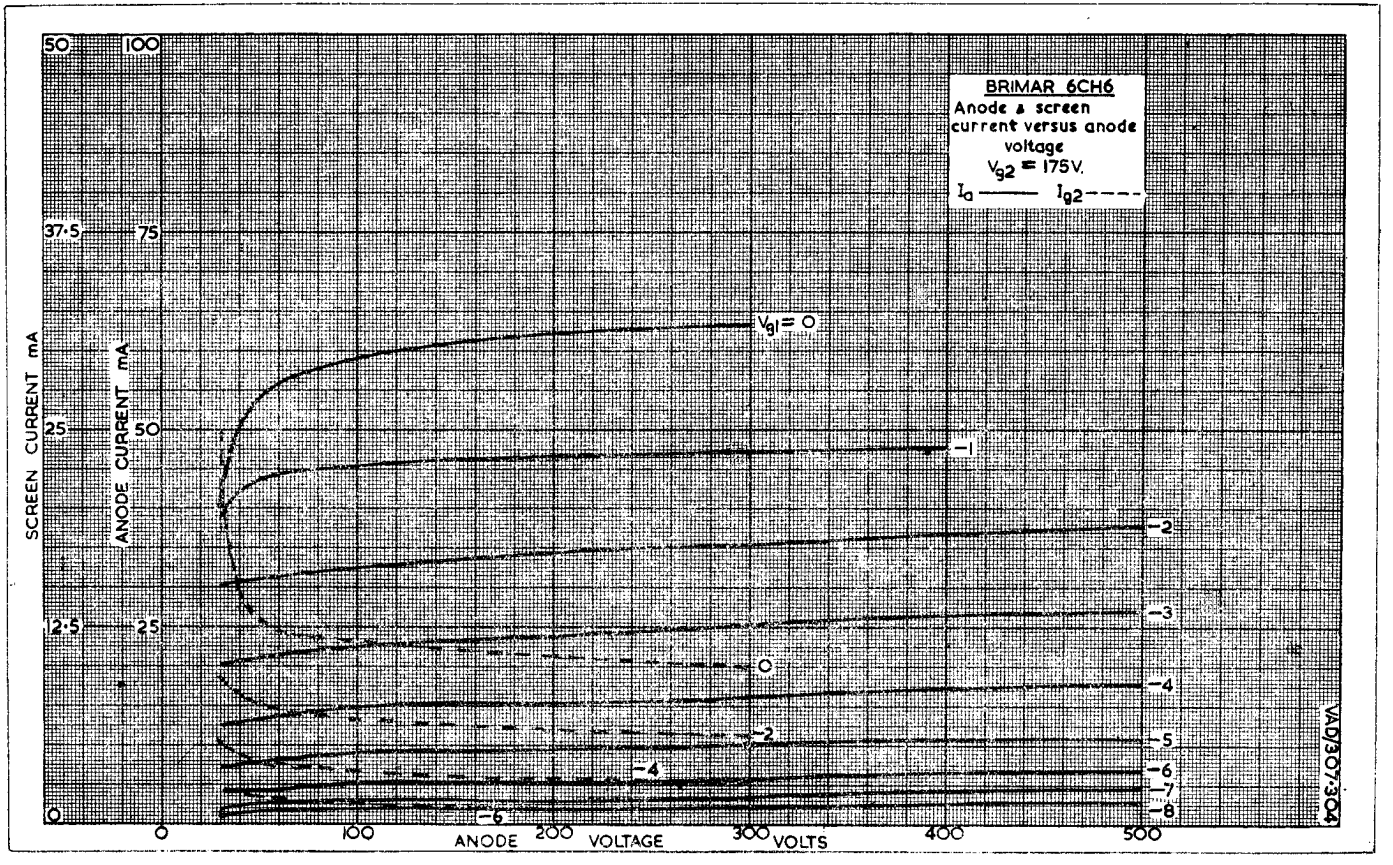
When using the valve with a positively pulsed grid care must be taken not to exceed the ratings given in paragraph 3.4, in particular attention must be paid to the note on grid dissipation.

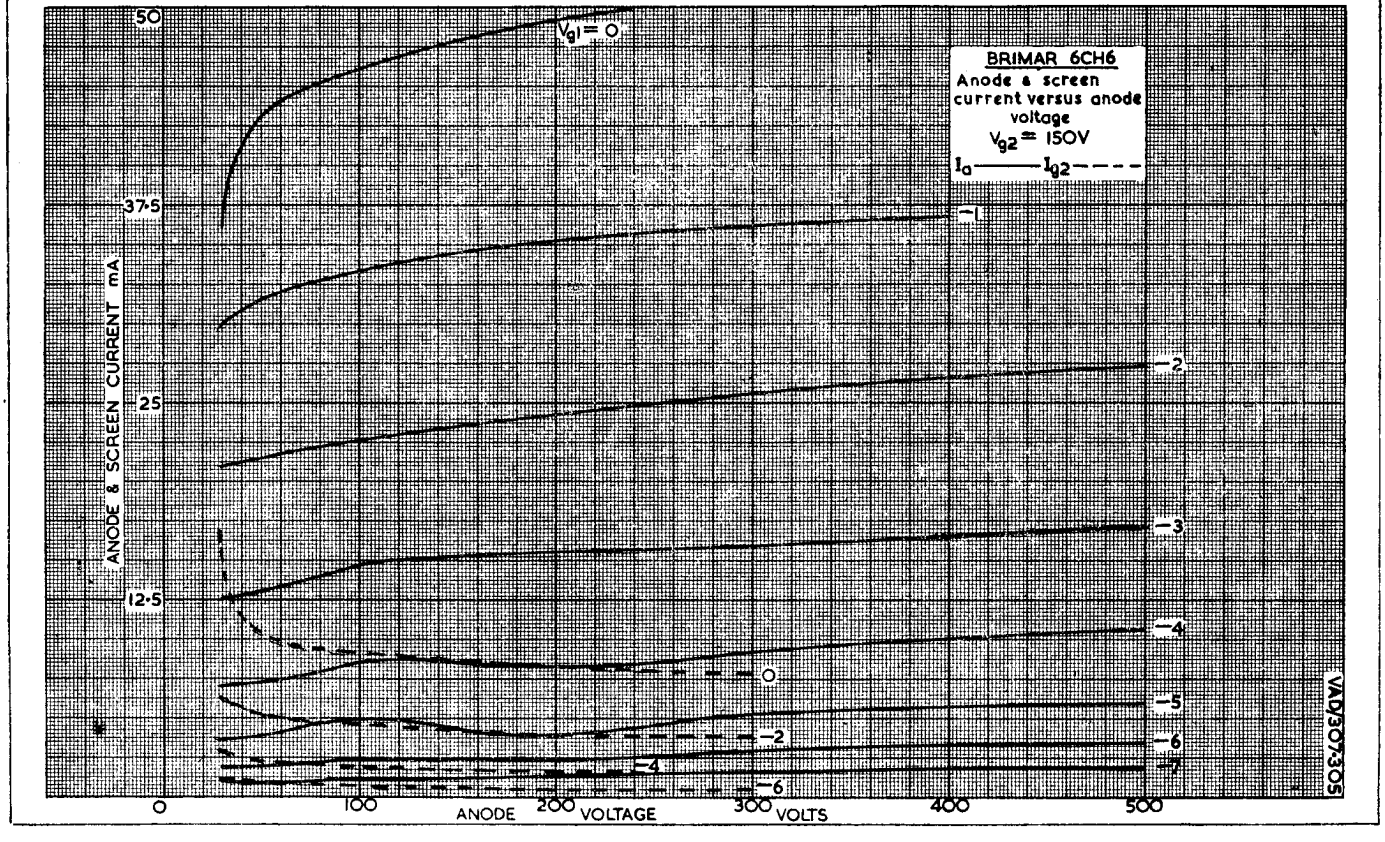

BRIMAR 6CH6
Anode & screen current versus anode voltage
V_{g2} =275 V.
I_a —— I_{g2} - - - -
V_{g1} =0
1
2
3
4
5
6
7
8
10
12
0
-2
-4
-6
-8
-10
100
75
50
25
0
100
200
300
400
500
ANODE & SCREEN CURRENT mA
ANODE VOLTAGE VOLTS
VAD/307-300

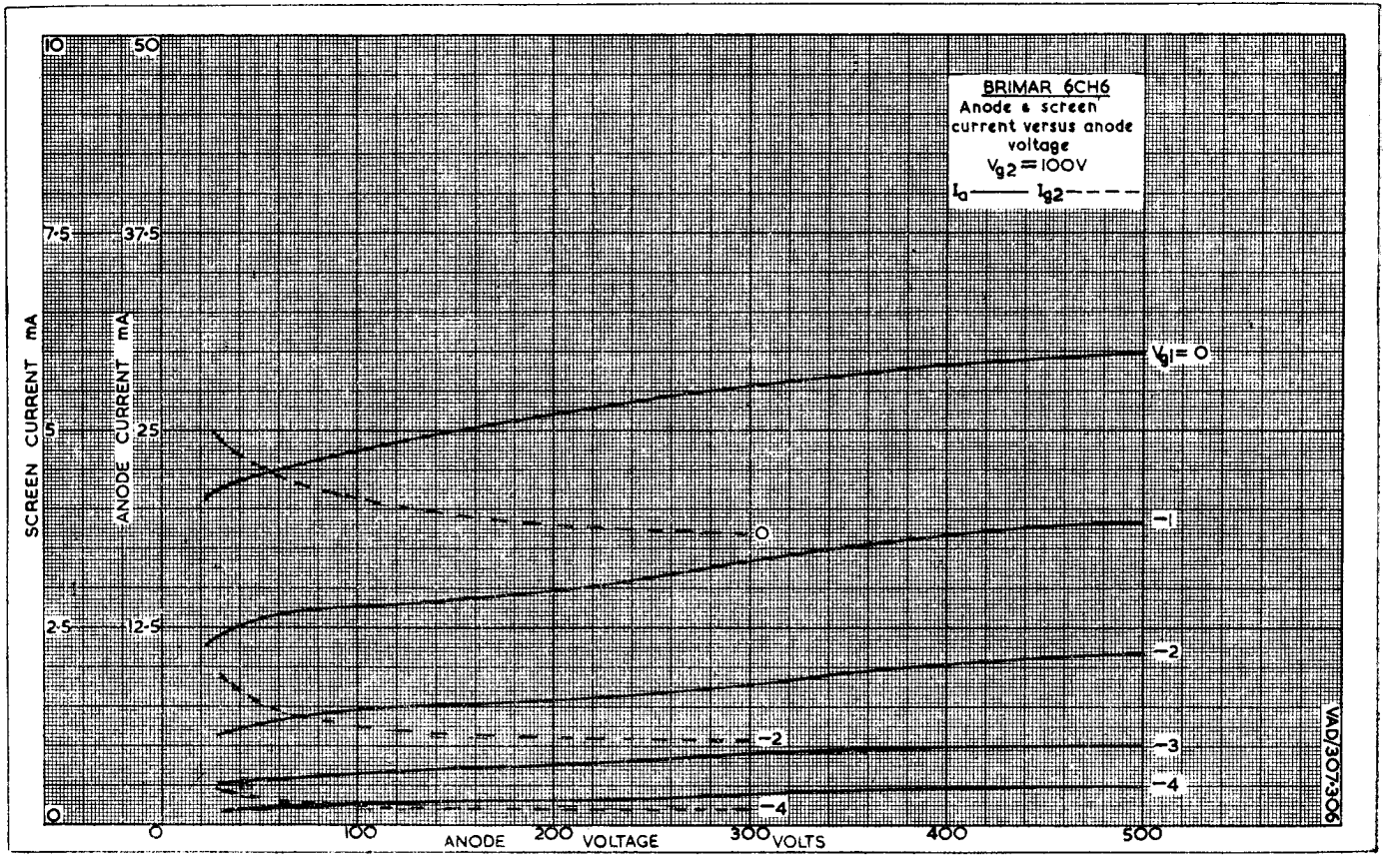

BRIMAR 6CH6
Anode & screen current versus anode voltage
V_{g2} = 250 V.
I_a —— I_{g2} - - - -
V_{g1} = 0
-1
-2
-3
-4
-5
-6
-7
-8
-10
-12
0
-2
-4
-6
-8
-10
100
75
50
25
0
ANODE & SCREEN CURRENT mA
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VAD/307-301

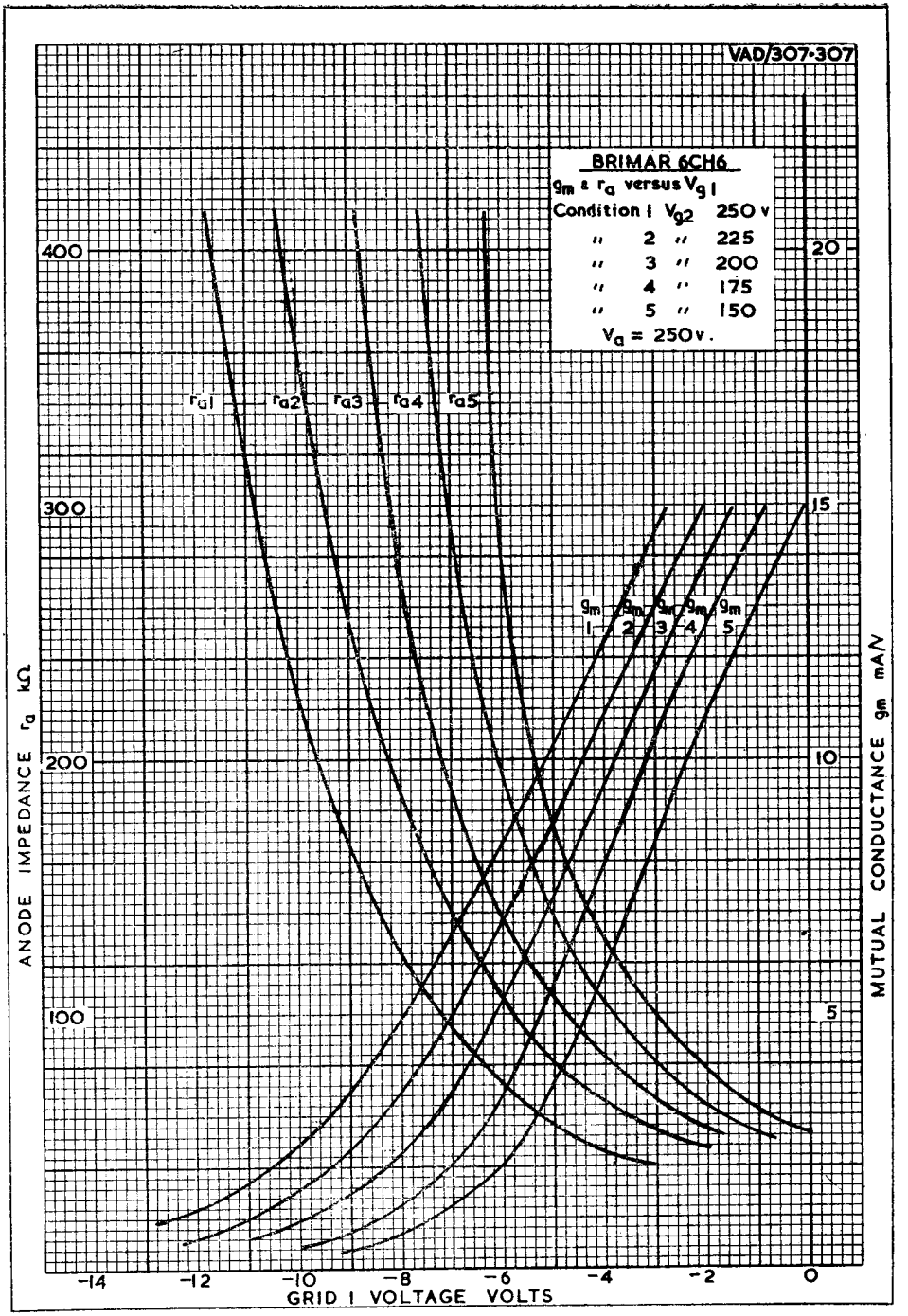

BRIMAR 6CH6
Anode & screen current versus anode voltage
V_{g2} = 225 V.
I_a —— I_{g2} - - - - -
V_{g1} = 0
-1
-2
-3
-4
-5
-6
-7
-8
-10
0
-2
-4
-6
-8
100
75
50
25
0
100
200
300
400
500
ANODE & SCREEN CURRENT mA
ANODE VOLTAGE VOLTS
VAD/307.302

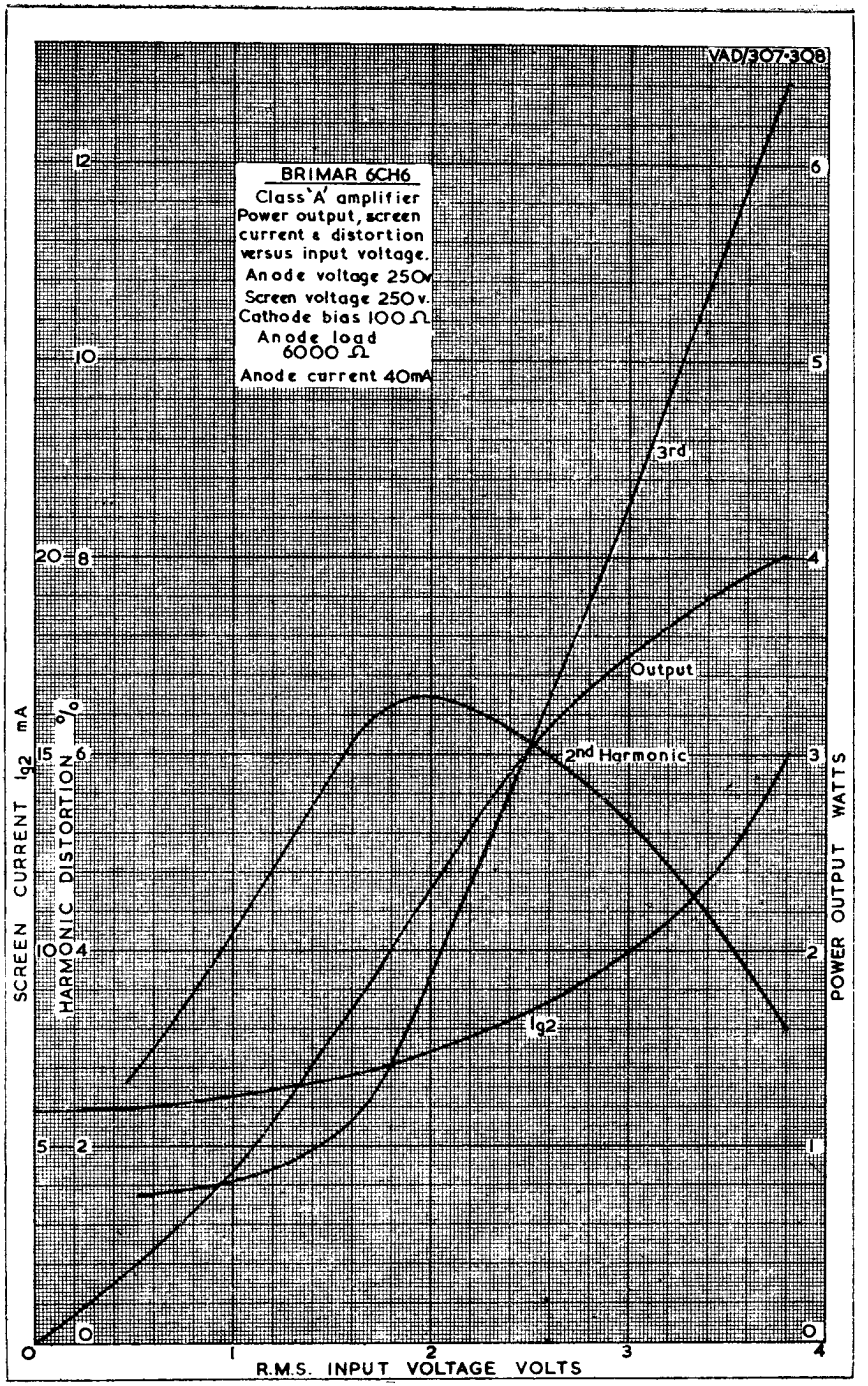

BRIMAR 6CH6
Anode & screen current versus anode voltage
V_{g2} = 200 V.
I_a —— I_{g2} - - - - -
SCREEN CURRENT mA
ANODE CURRENT mA
50
100
37·5
75
25
50
12·5
25
0
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
V_{g1} = 0
-1
-2
-3
-4
-5
-6
-7
-8
-10
0
-2
-3
-4
-6
-7
-8
VAD/307-303

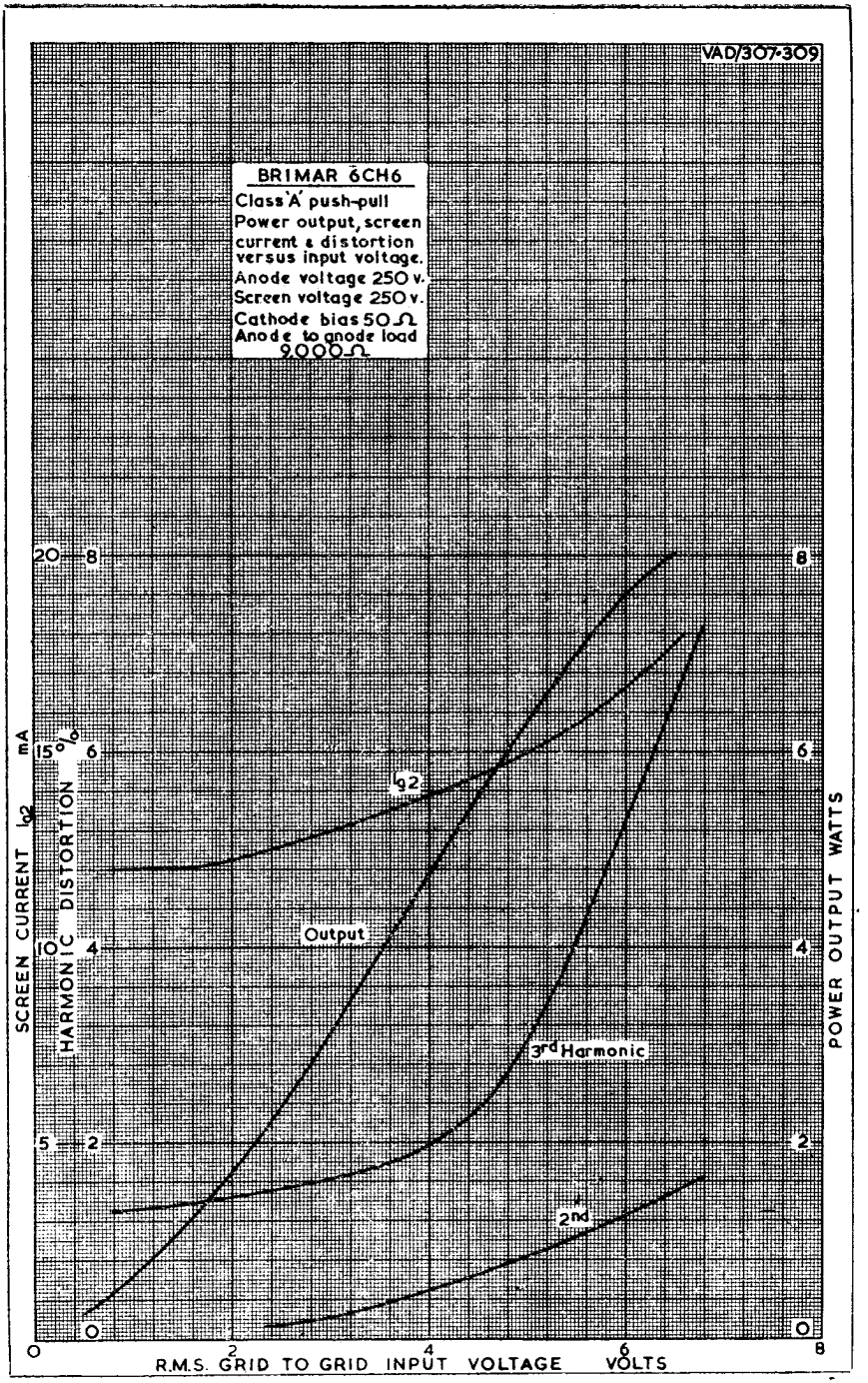

BRIMAR 6CH6
Anode & screen current versus anode voltage
V_{g2} = 175V.
I_a ——— I_{g2} - - - -
SCREEN CURRENT mA
ANODE CURRENT mA
50
100
37·5
75
25
50
12·5
25
0
V_{g1} = 0
-1
-2
-3
0
-4
-2
-5
-4
-6
-7
-6
-8
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VAD/307-304

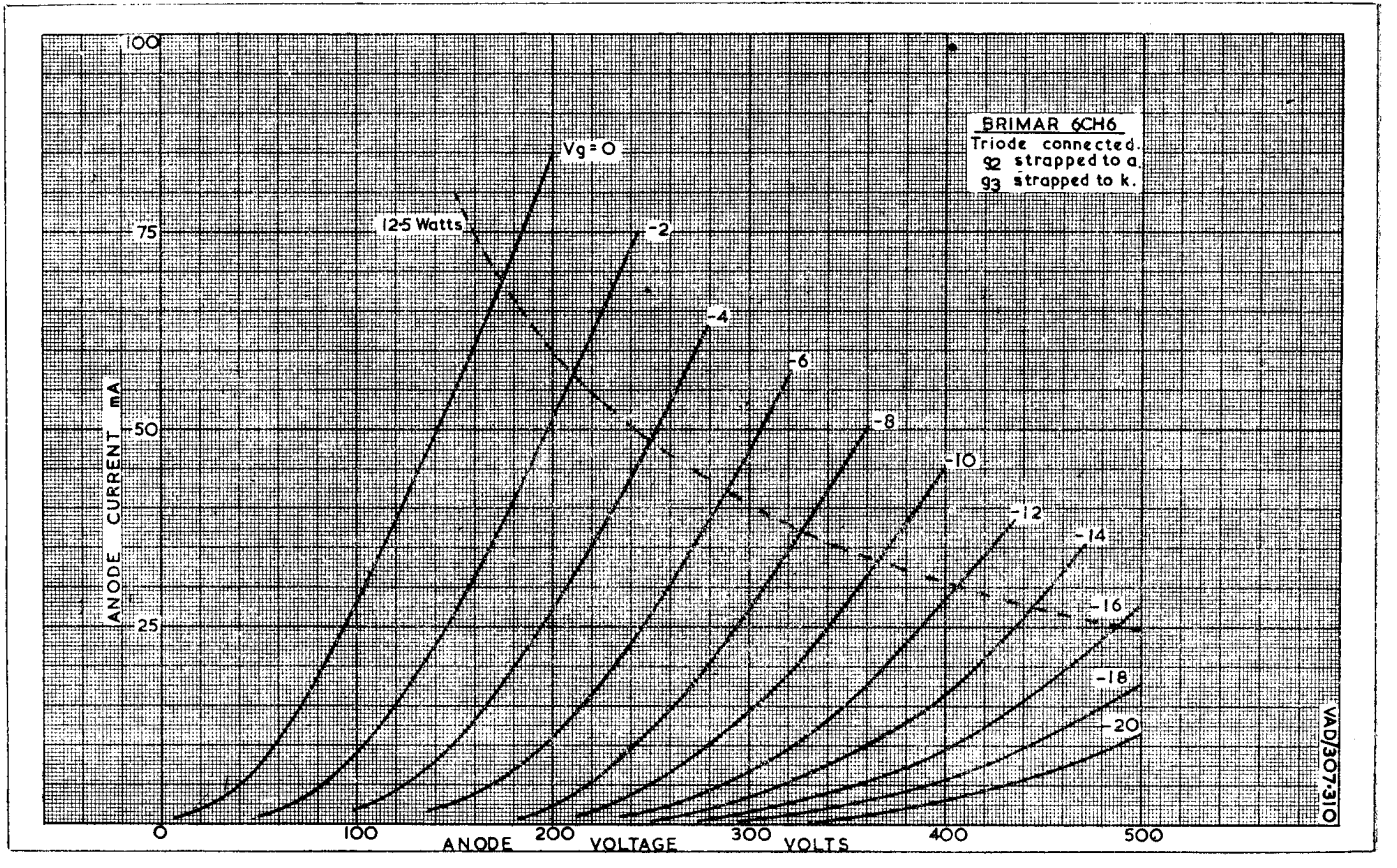

BRIMAR 6CH6
Anode & screen current versus anode voltage
V_{g2} = 150V
I_a ——— I_{g2} - - -
50
37·5
25
12·5
ANODE & SCREEN CURRENT mA
V_{g1} = 0
−1
−2
−3
−4
0
−5
−2
−6
−4
−7
−6
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VAD307305

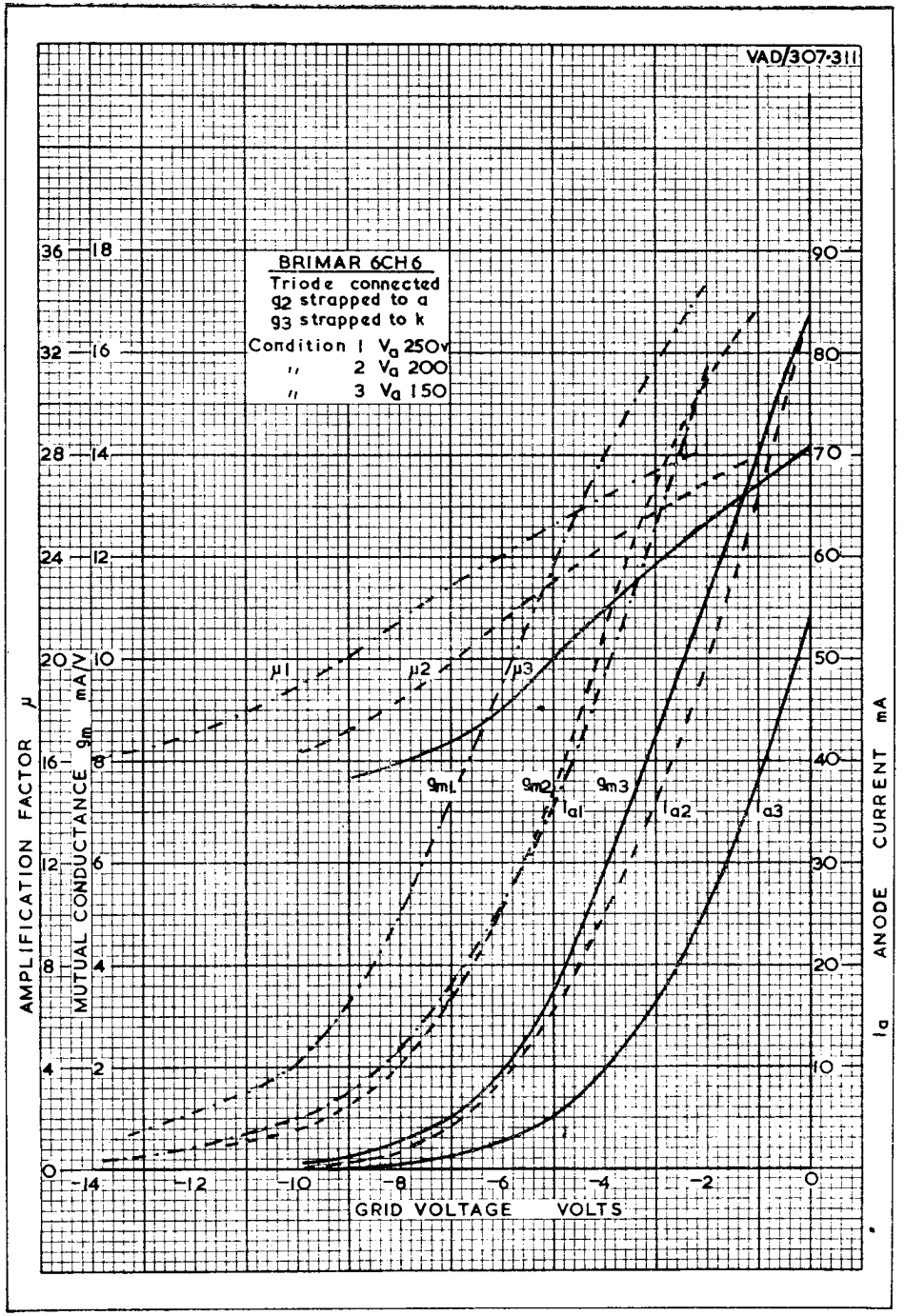

BRIMAR 6CH6
Anode & screen current versus anode voltage
V_{g2} = 100V
I_a —— I_{g2} - - -
SCREEN CURRENT mA
ANODE CURRENT mA
10
50
7·5
37·5
5
25
2·5
12·5
0
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
V_{g1} = 0
−1
−2
−3
−4
VAD/3072-36

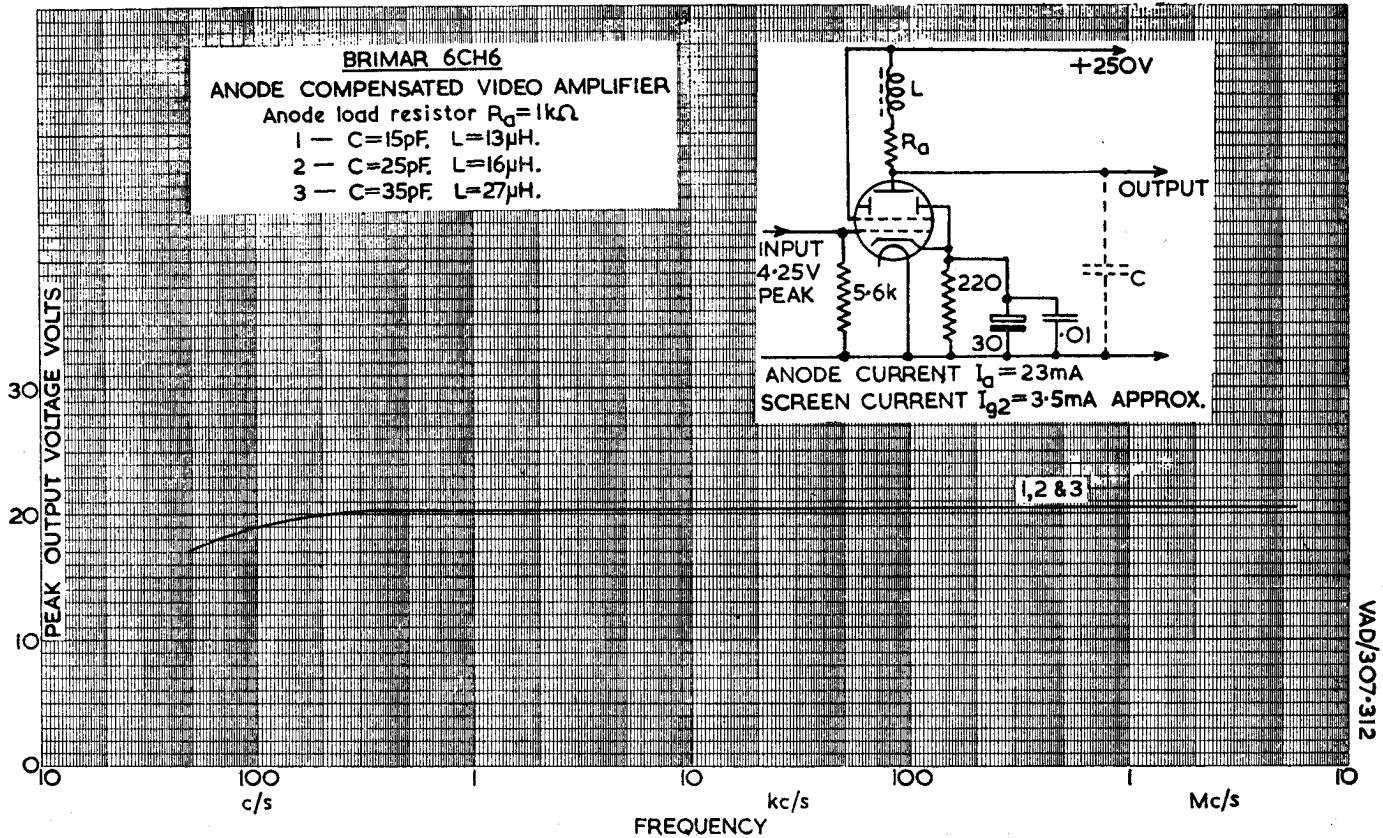

VAD/307-307
BRIMAR 6CH6
g_m & r_a versus V_{g1}
Condition 1 V_{g2} 250 v
" 2 " 225
" 3 " 200
" 4 " 175
" 5 " 150
V_a = 250v.
r_{a1} r_{a2} r_{a3} r_{a4} r_{a5}
g_{m1} g_{m2} g_{m3} g_{m4} g_{m5}
400
300
200
100
20
15
10
5
-14 -12 -10 -8 -6 -4 -2 0
GRID 1 VOLTAGE VOLTS
ANODE IMPEDANCE r_a kΩ
MUTUAL CONDUCTANCE g_m mA/V

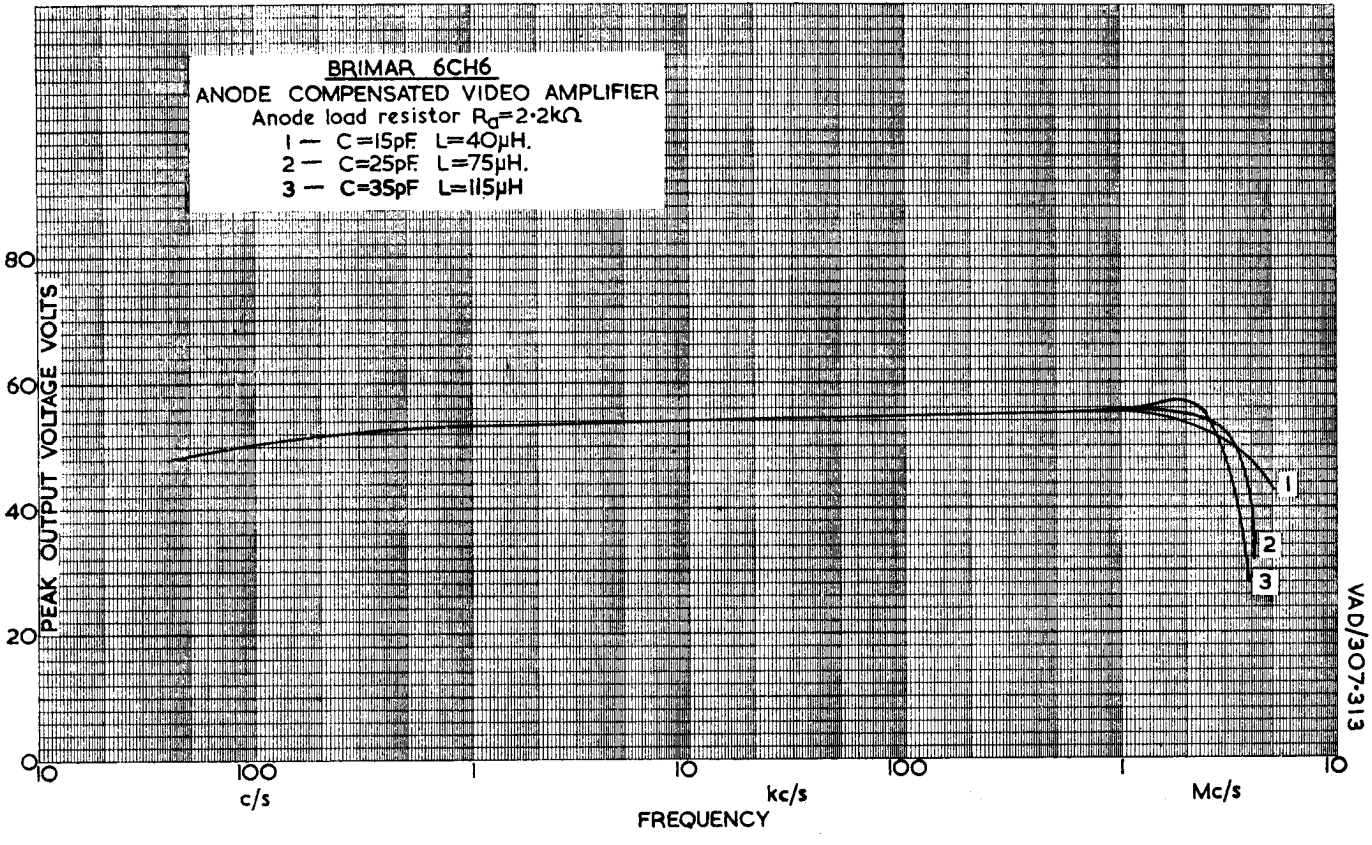

VAD/307-308
BRIMAR 6CH6
Class 'A' amplifier
Power output, screen current & distortion versus input voltage.
Anode voltage 250v
Screen voltage 250v.
Cathode bias 100 Ω
Anode load 6000 Ω
Anode current 40mA
3rd
Output
2nd Harmonic
I_{g2}
SCREEN CURRENT I_{g2} mA
HARMONIC DISTORTION %
POWER OUTPUT WATTS
R.M.S. INPUT VOLTAGE VOLTS
0
1
2
3
4
5
6
8
10
12
15
20

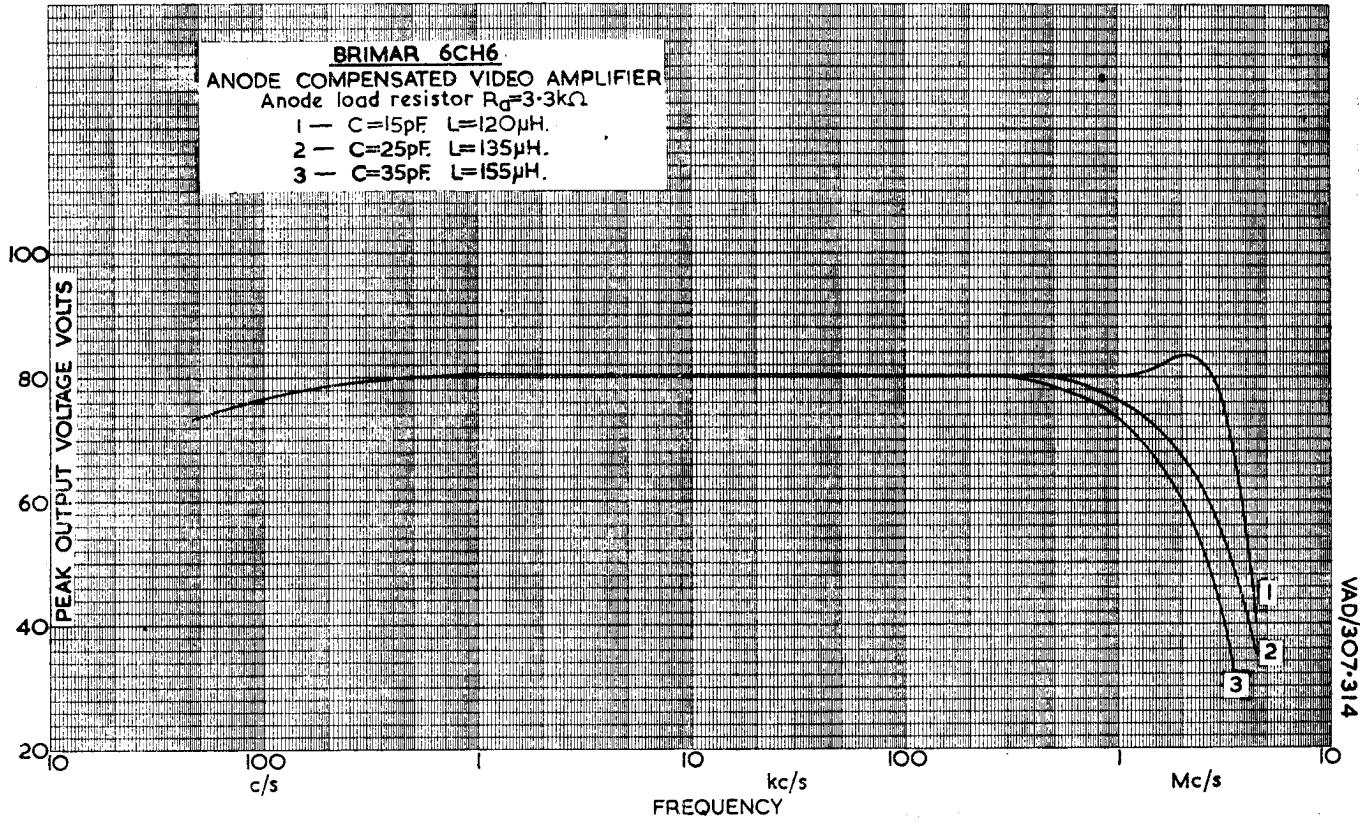

VAD/307-309
BRIMAR 6CH6
Class 'A' push-pull
Power output, screen current & distortion versus input voltage.
Anode voltage 250 v.
Screen voltage 250 v.
Cathode bias 50 Ω
Anode to anode load 9,000 Ω
SCREEN CURRENT I_{g2} mA
HARMONIC DISTORTION %
POWER OUTPUT WATTS
I_{g2}
Output
3rd Harmonic
2nd
R.M.S. GRID TO GRID INPUT VOLTAGE VOLTS
0
2
4
6
8
20
15
10
5

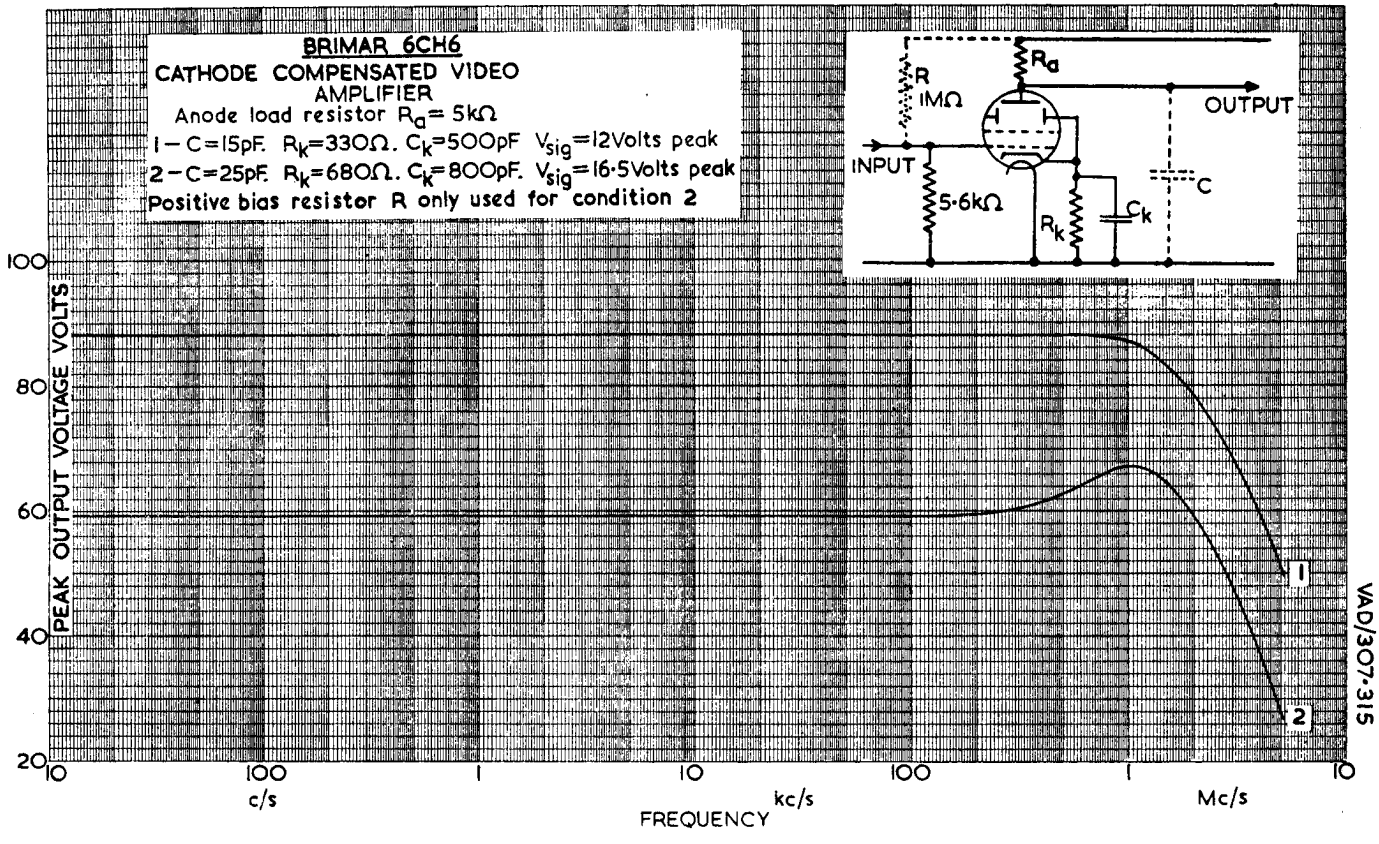

BRIMAR 6CH6
Triode connected.
g2 strapped to a.
g3 strapped to k.
Vg = 0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
12·5 Watts
ANODE CURRENT mA
100
75
50
25
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VAD/307-310


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
μ1
μ2
μ3
gm1
gm2
gm3
Ia1
Ia2
Ia3
AMPLIFICATION FACTOR μ
MUTUAL CONDUCTANCE gm mA/V
Ia ANODE CURRENT mA
GRID VOLTAGE VOLTS
36
18
32
16
28
14
24
12
20
10
16
8
12
6
8
4
4
2
0
90
80
70
60
50
40
30
20
10
-14
-12
-10
-8
-6
-4
-2
0

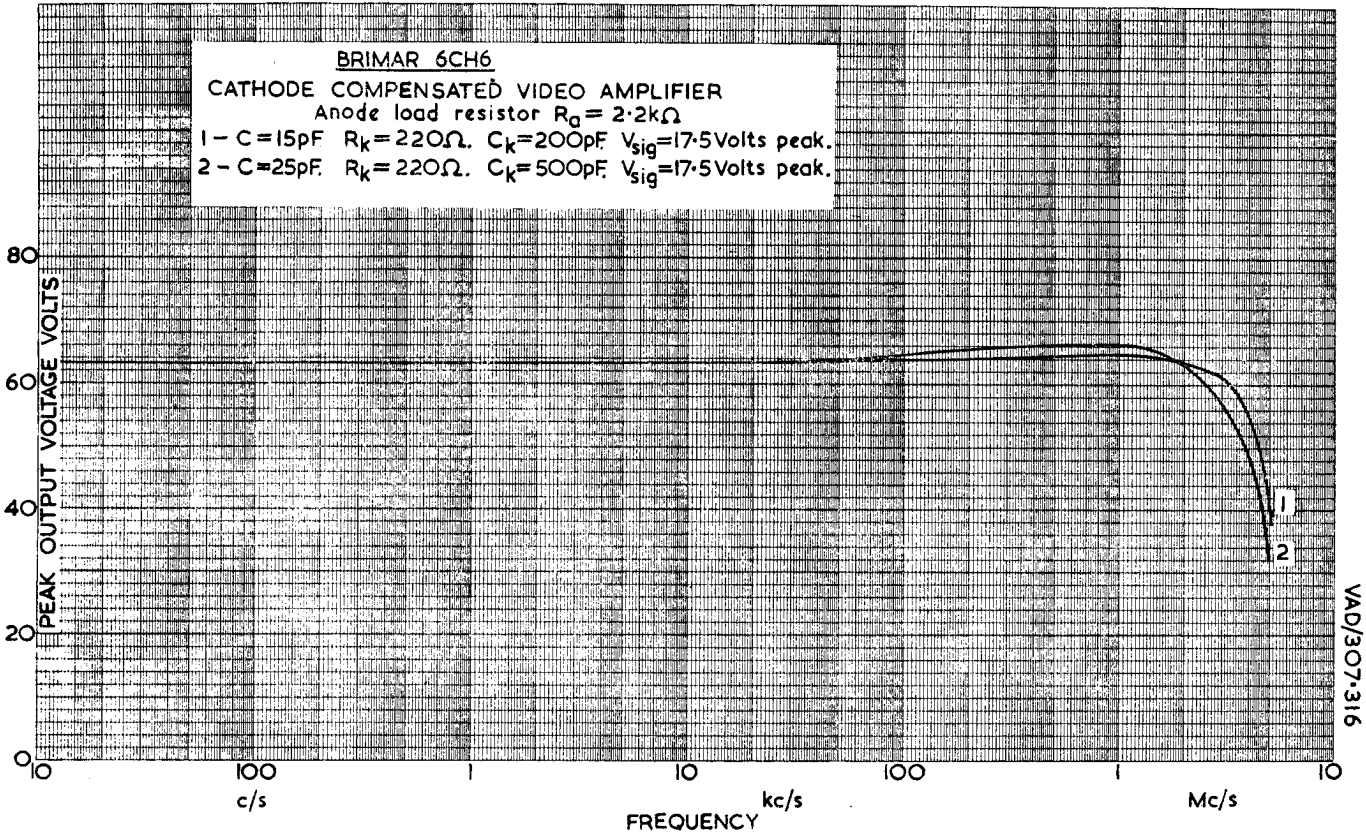

BRIMAR 6CH6
ANODE COMPENSATED VIDEO AMPLIFIER
Anode load resistor R_a=1kΩ
1 — C=15pF. L=13μH.
2 — C=25pF. L=16μH.
3 — C=35pF. L=27μH.
+250V
L
R_a
OUTPUT
INPUT
4·25V
PEAK
5·6k
220
C
30
·01
ANODE CURRENT I_a=23mA
SCREEN CURRENT I_{g2}=3·5mA APPROX.
1,2 &3
PEAK OUTPUT VOLTAGE VOLTS
0
10
20
30
10
100
1
10
100
1
10
c/s
kc/s
Mc/s
FREQUENCY
VAD/307·312

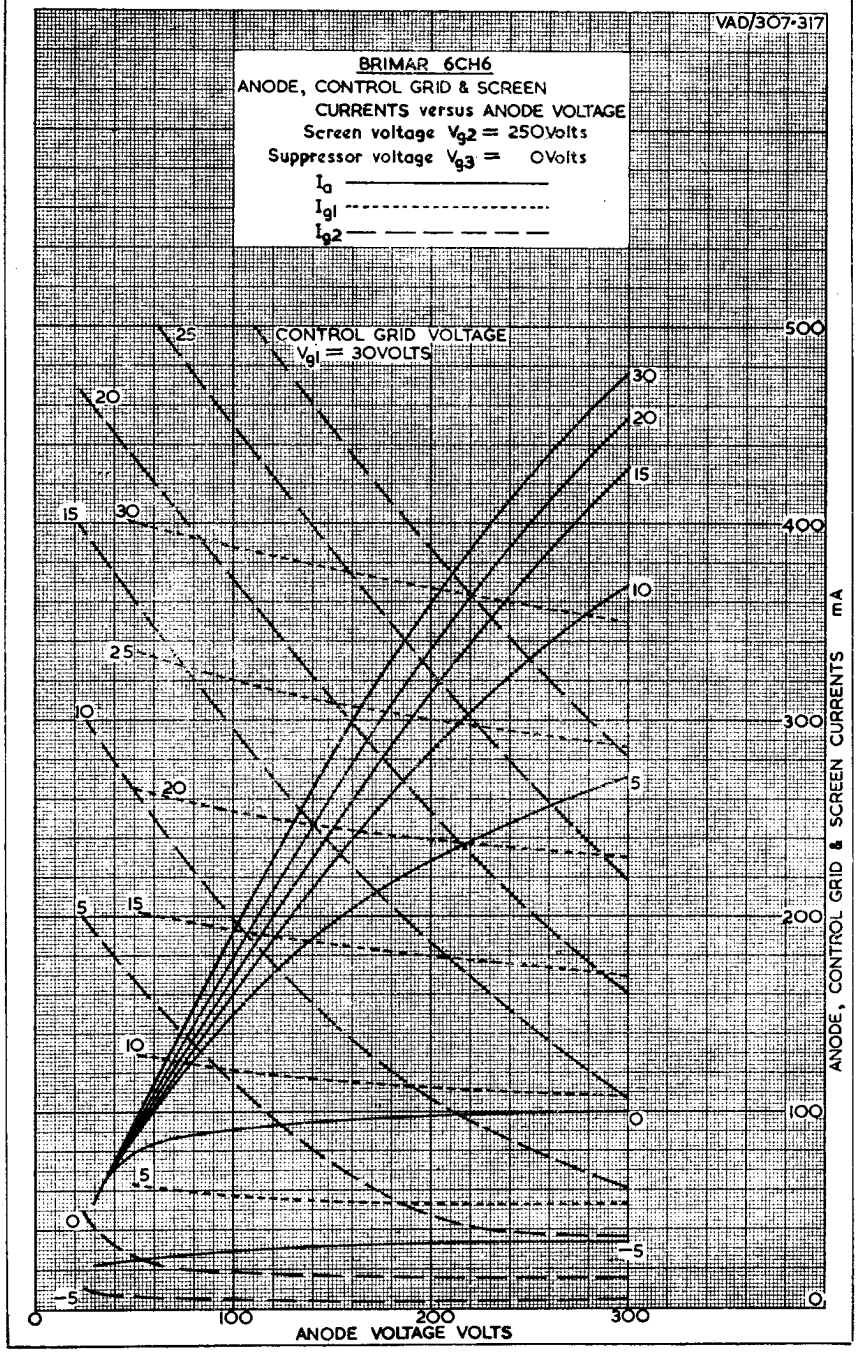

BRIMAR 6CH6
ANODE COMPENSATED VIDEO AMPLIFIER
Anode load resistor R_a=2·2kΩ
1 — C=15pF L=40μH.
2 — C=25pF L=75μH.
3 — C=35pF L=115μH
PEAK OUTPUT VOLTAGE VOLTS
0
20
40
60
80
10
100
1
10
100
1
10
c/s
kc/s
Mc/s
FREQUENCY
1
2
3
VAD/307-313


BRIMAR 6CH6
ANODE COMPENSATED VIDEO AMPLIFIER
Anode load resistor R_a=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
1
10
100
1
10
c/s
kc/s
Mc/s
FREQUENCY
1
2
3
VAD/307·314


BRIMAR 6CH6
CATHODE COMPENSATED VIDEO AMPLIFIER
Anode load resistor R_a = 5kΩ
1 – C=15pF. R_k=330Ω. C_k=500pF V_{sig}=12Volts peak
2 – C=25pF. R_k=680Ω. C_k=800pF. V_{sig}=16·5Volts peak
Positive bias resistor R only used for condition 2
R
1MΩ
R_a
OUTPUT
INPUT
5·6kΩ
R_k
C_k
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
0
20
40
60
80
10
100
1
10
100
1
10
c/s
kc/s
Mc/s
FREQUENCY
1
2
VAD/307·316


BRIMAR 6CH6
ANODE, CONTROL GRID & SCREEN
CURRENTS versus ANODE VOLTAGE
Screen voltage V_{g2} = 250Volts
Suppressor voltage V_{g3} = 0Volts
I_a
I_{g1}
I_{g2}
CONTROL GRID VOLTAGE
V_{g1} = 30VOLTS
25
20
15
30
25
20
15
10
5
0
−5
30
20
15
10
5
0
−5
500
400
300
200
100
0
0
100
200
300
ANODE VOLTAGE VOLTS
ANODE, CONTROL GRID & SCREEN CURRENTS mA

BRIMAR

RECEIVING VALVE

12AH8

APPLICATION REPORT VAD/520.2

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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 $c_{glh, all}$	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_{glh} 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_{glh} 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_{glh}	320·22
Ditto versus V_{glh} 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_{glh}	—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_{glh}	—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 ±75 kc/s deviation.

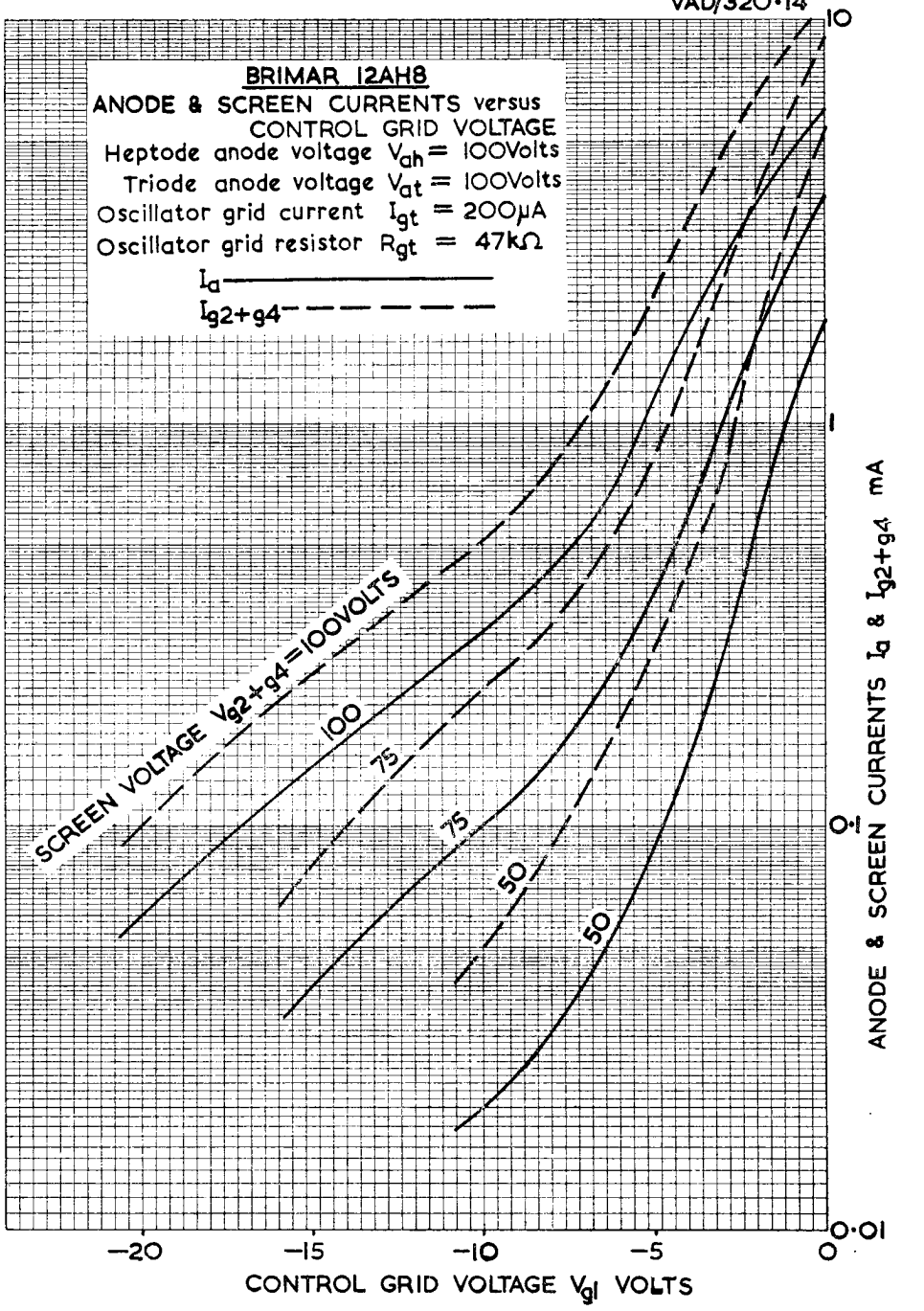
The coil details are as follows. Both coils are wound with 18 SWG tinned copper wire. The aerial coil consists of 2 turns, 1/2 in. internal diameter, 3/8 in. long. The tappings are, aerial 1/2 turn from earthy end, signal grid 1-3/4 turns from earthy end. The oscillator coil primary is wound on a 1/4 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.

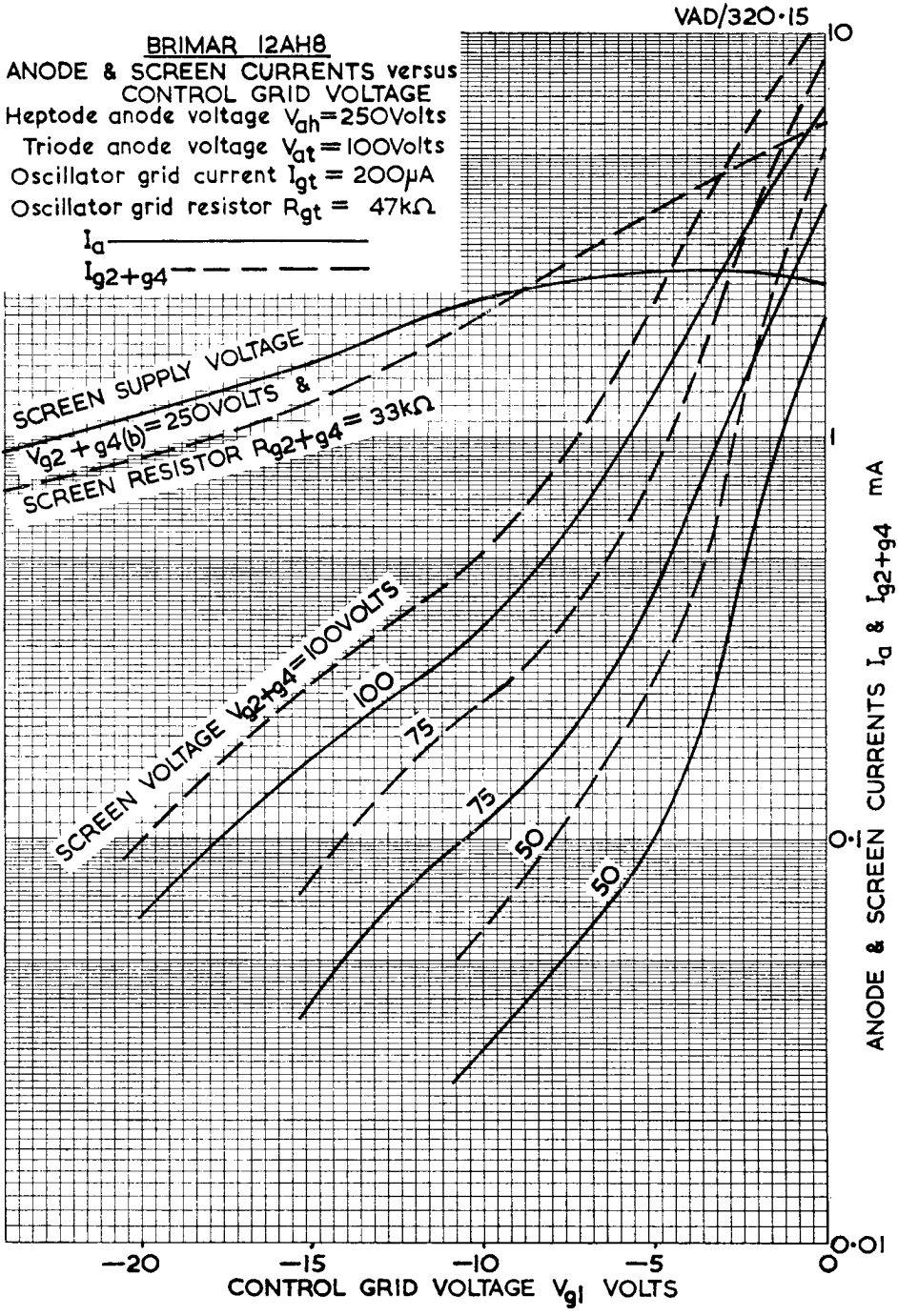
The oscillator frequency is set lower than the signal frequency by the difference of the IF, as this simplifies the requirements for frequency stability. To compensate for the change in capacity across the oscillator coil as the circuit warms up in the cabinet a negative temperature coefficient condenser 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.

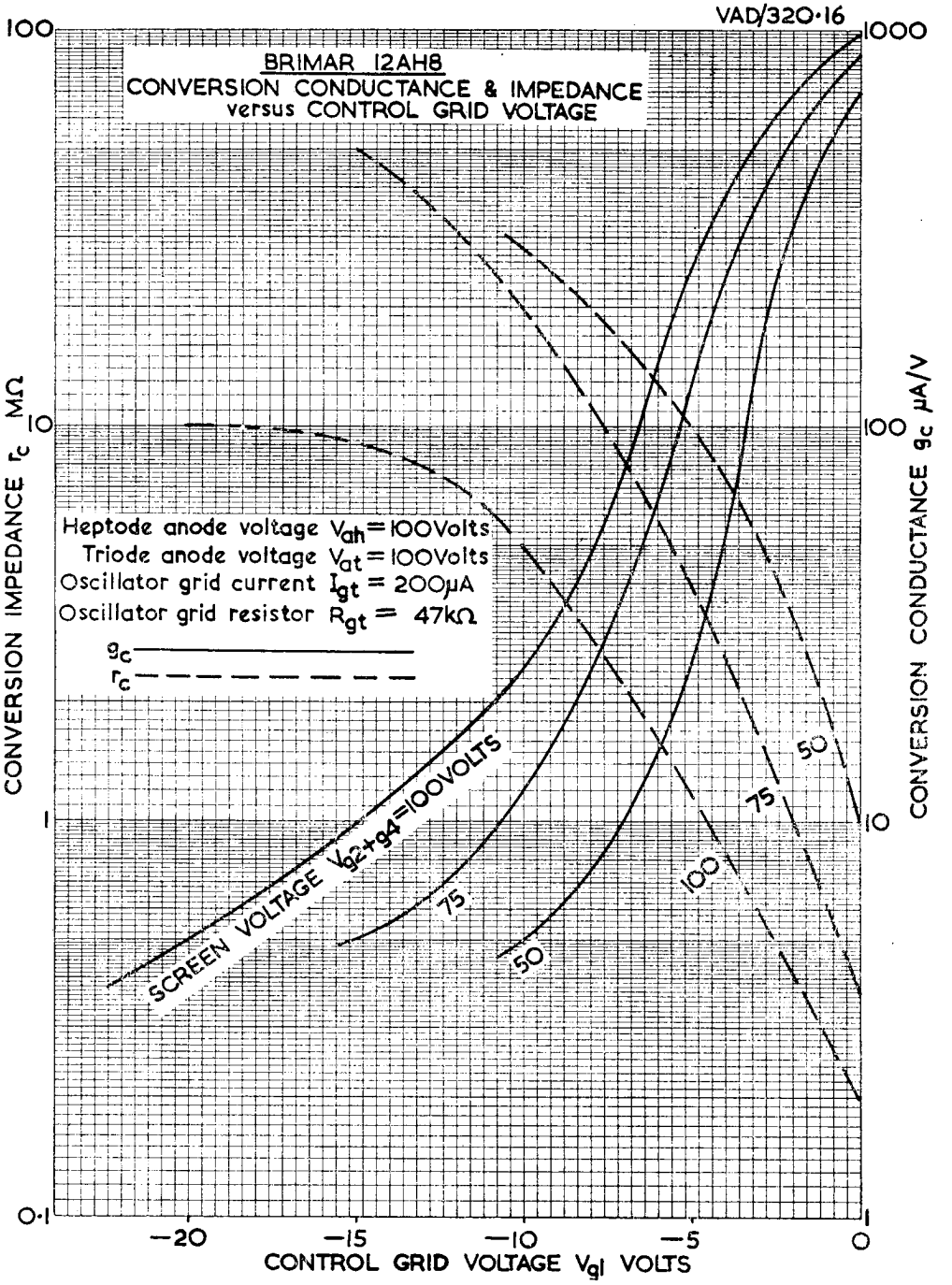
The purpose of the choke in the live filament lead is to reduce the possibility of regeneration at IF when, as is often the case, a high gain IF amplifier follows the mixer.

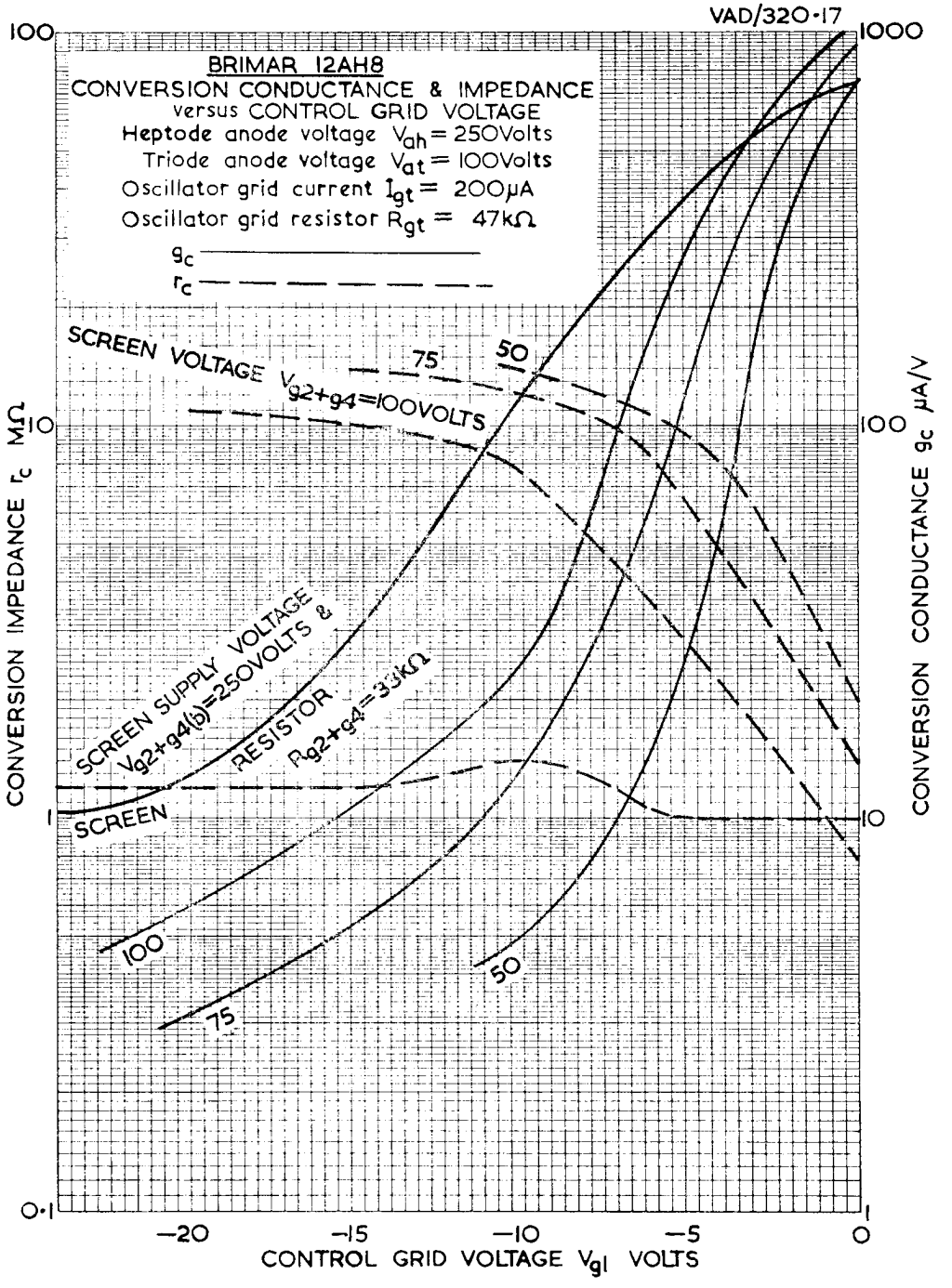
5.0 Other Applications: Triode Heptode frequency changer valves are not generally used for other than their intended purpose, as their characteristics are so specialised as to make them of little use in other applications.

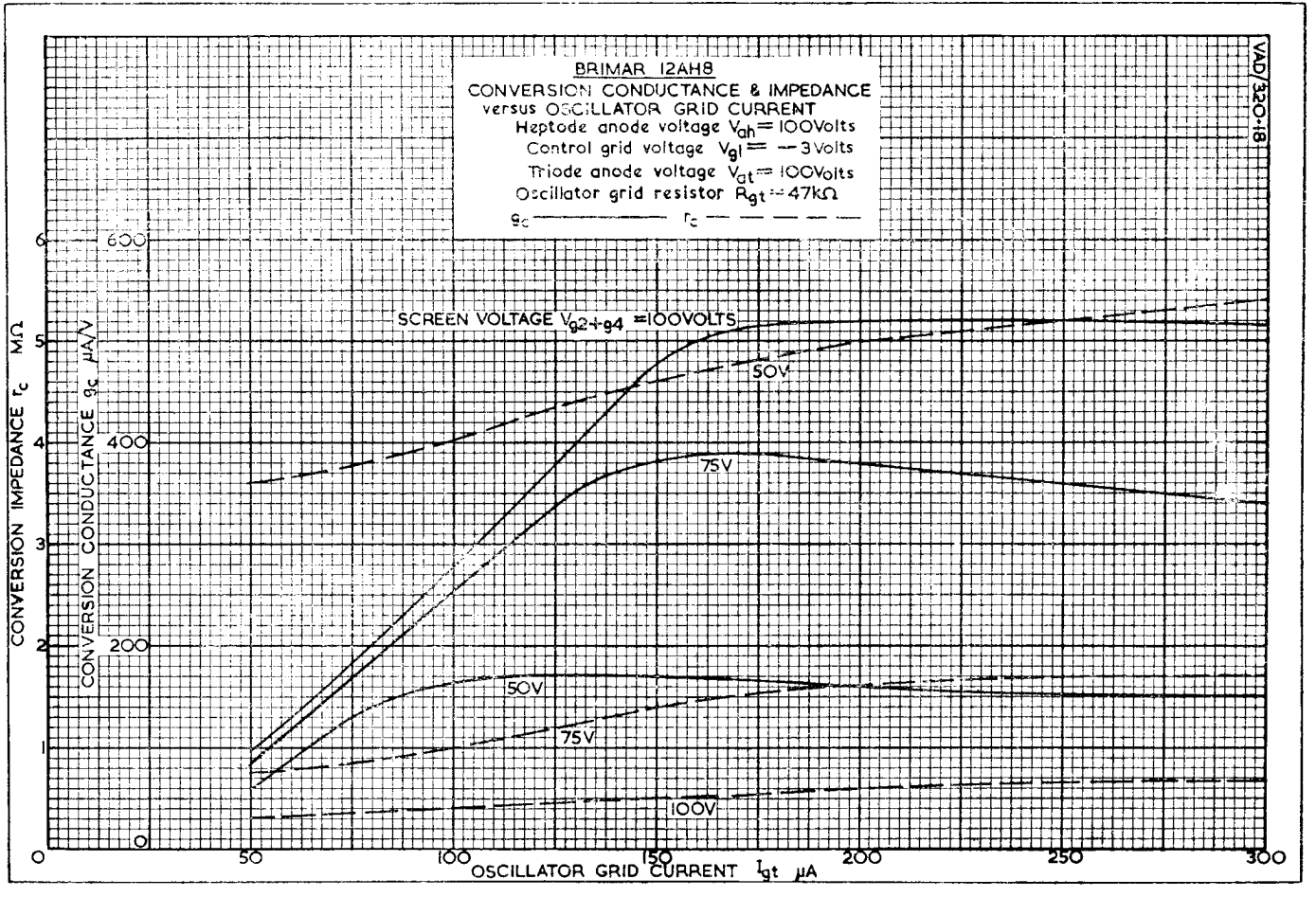
One field, however, where they often find use is in circuits where control is required individually and/or jointly from two separate signals without mutual interaction. Signals are supplied to the heptode grid 1 and grid 3, so the anode current is controlled by either signal and is also a function of 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.

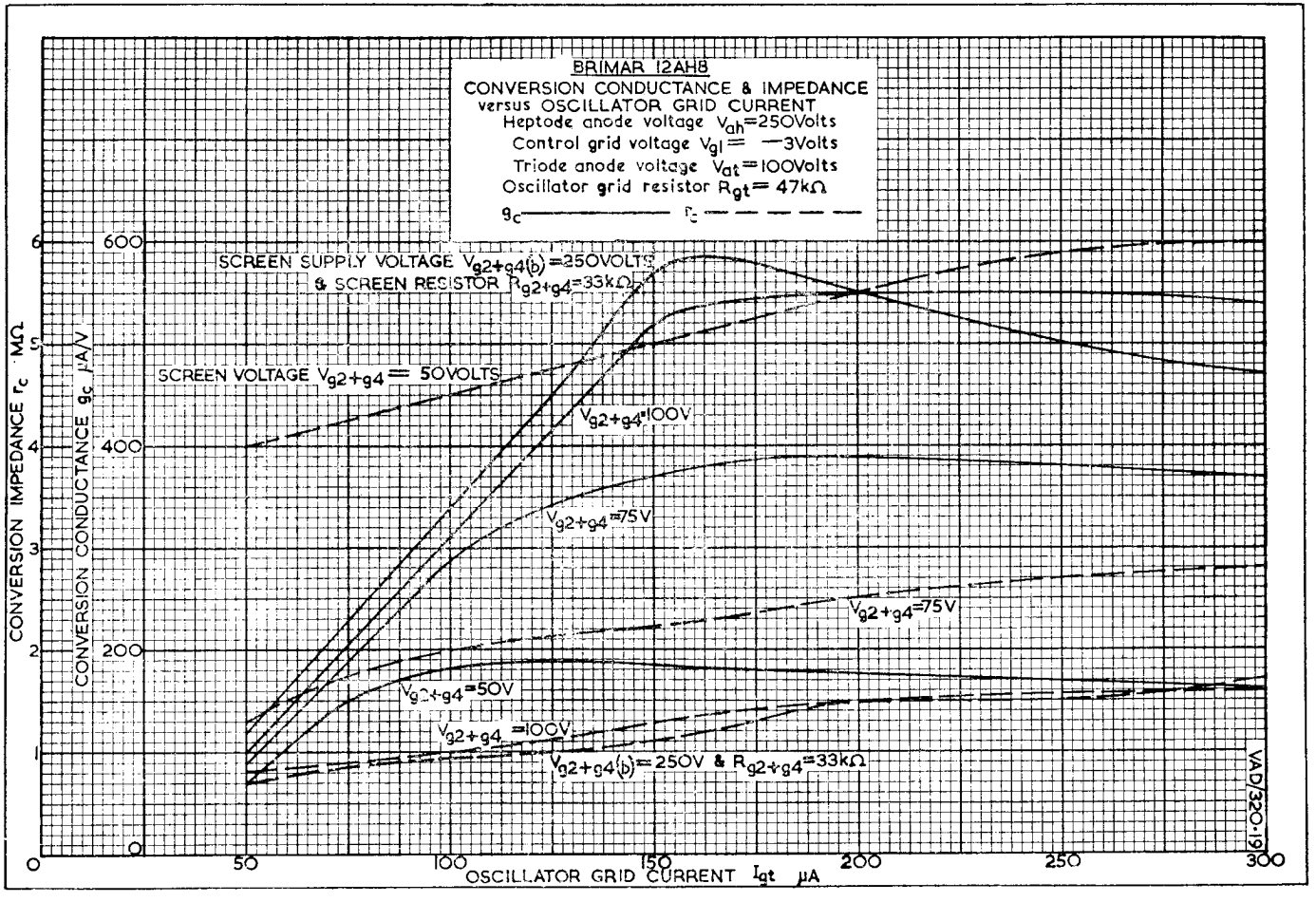

BRIMAR 12AH8
ANODE & SCREEN CURRENTS versus CONTROL GRID VOLTAGE
Heptode anode voltage V_{ah} = 100Volts
Triode anode voltage V_{at} = 100Volts
Oscillator grid current I_{gt} = 200μA
Oscillator grid resistor R_{gt} = 47kΩ
I_a
I_{g2+g4}
SCREEN VOLTAGE V_{g2+g4} = 100VOLTS
100
75
75
50
50
10
1
0·1
0·01
−20
−15
−10
−5
0
CONTROL GRID VOLTAGE V_{g1} VOLTS
ANODE & SCREEN CURRENTS I_a & I_{g2+g4} mA

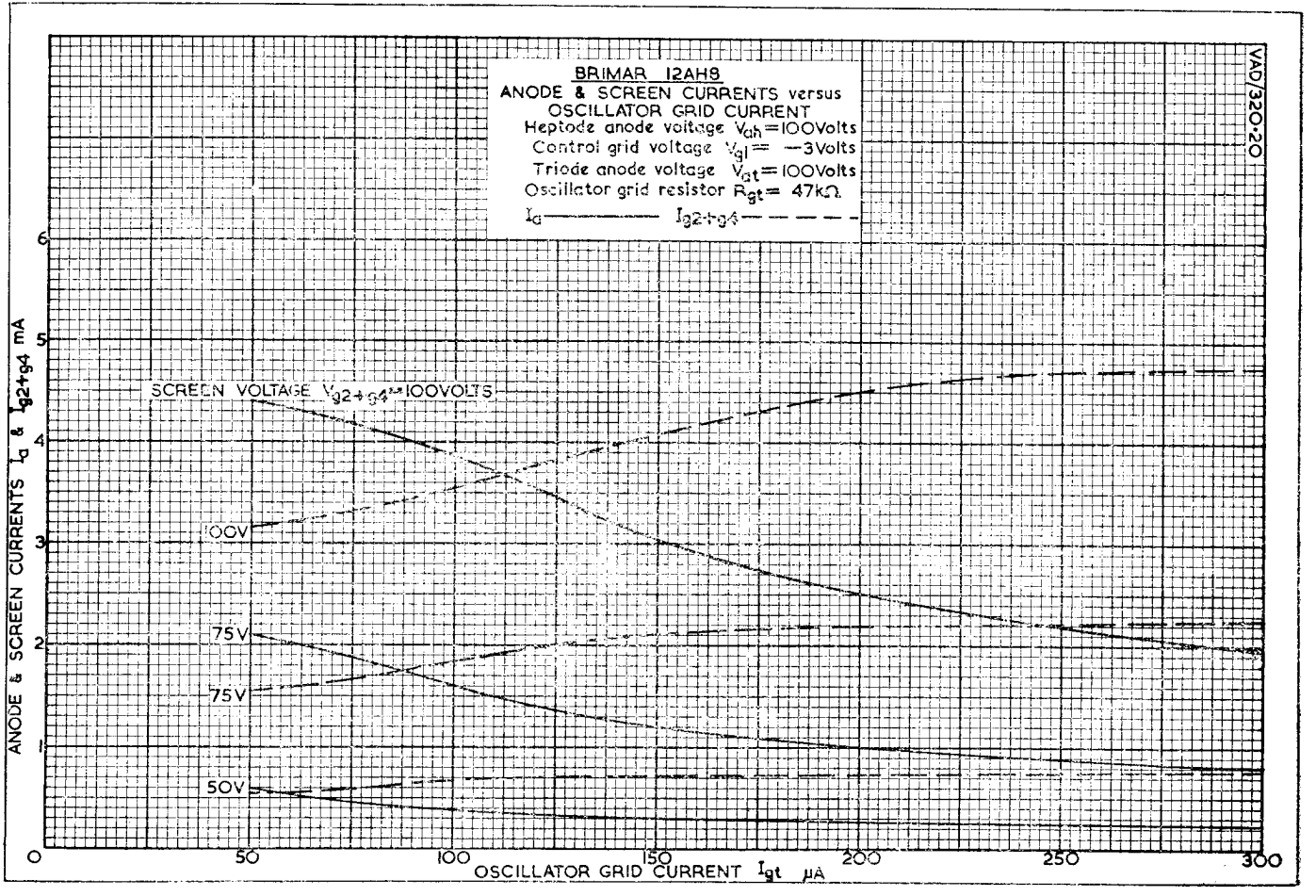

VAD/320·15
BRIMAR 12AH8
ANODE & SCREEN CURRENTS versus CONTROL GRID VOLTAGE
Heptode anode voltage V_{ah}=250Volts
Triode anode voltage V_{at}=100Volts
Oscillator grid current I_{gt} = 200μA
Oscillator grid resistor R_{gt} = 47kΩ
I_a
I_{g2+g4}
SCREEN SUPPLY VOLTAGE $V_{g2+g4(b)}$=250VOLTS & SCREEN RESISTOR R_{g2+g4}= 33kΩ
SCREEN VOLTAGE V_{g2+g4}=100VOLTS
100
75
75
50
50
10
1
0·1
0·01
0
−5
−10
−15
−20
CONTROL GRID VOLTAGE V_{g1} VOLTS
ANODE & SCREEN CURRENTS I_a & I_{g2+g4} mA

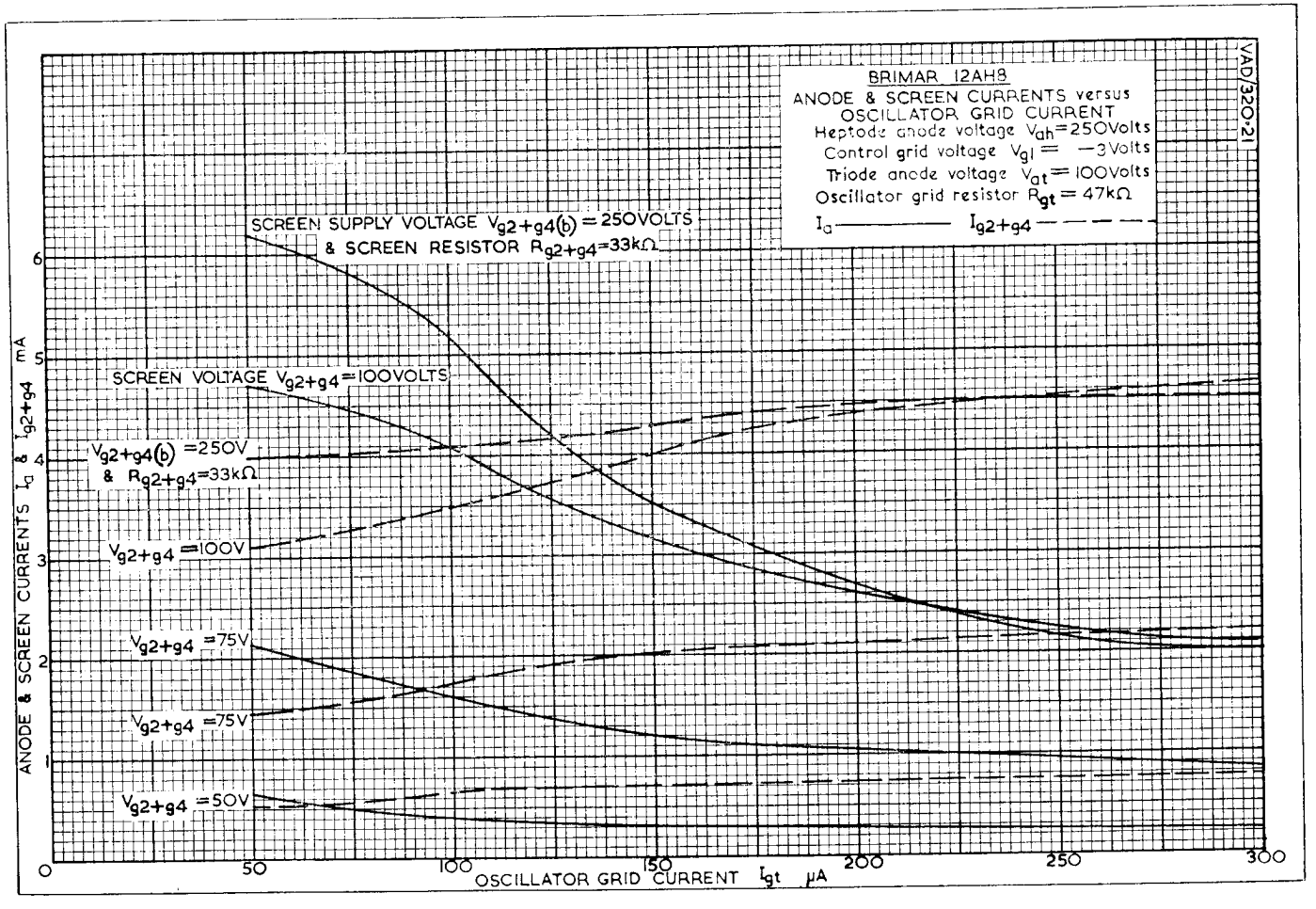

VAD/320·16
BRIMAR 12AH8
CONVERSION CONDUCTANCE & IMPEDANCE
versus CONTROL GRID VOLTAGE
Heptode anode voltage V_{ah} = 100Volts
Triode anode voltage V_{at} = 100Volts
Oscillator grid current I_{gt} = 200μA
Oscillator grid resistor R_{gt} = 47kΩ
g_c
r_c
SCREEN VOLTAGE V_{g2+g4}=100VOLTS
75
50
100
75
50
CONVERSION IMPEDANCE r_c MΩ
CONVERSION CONDUCTANCE g_c μA/V
100
10
1
0·1
1000
100
10
1
−20
−15
−10
−5
0
CONTROL GRID VOLTAGE V_{g1} VOLTS

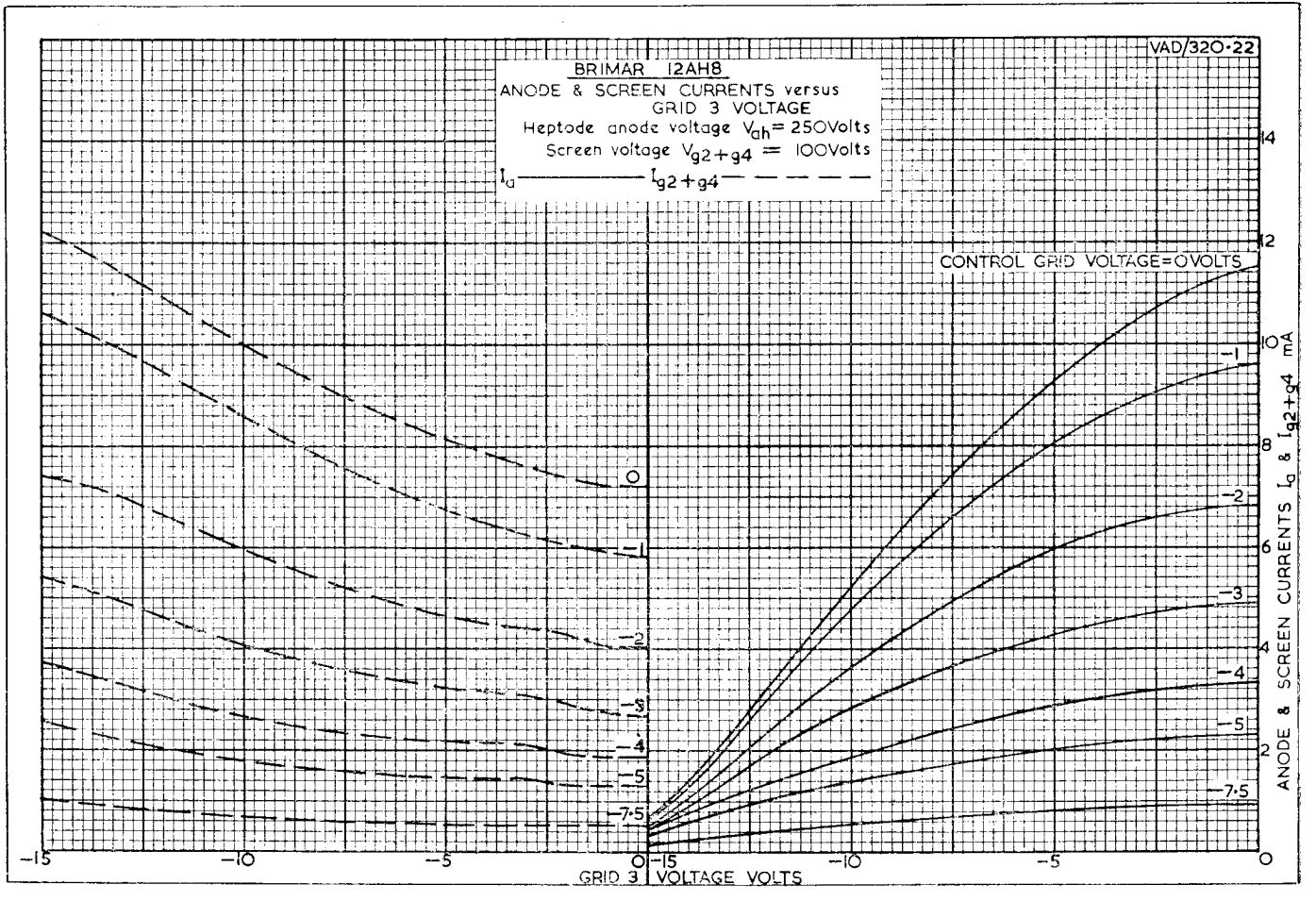

VAD/320·17
BRIMAR 12AH8
CONVERSION CONDUCTANCE & IMPEDANCE
versus CONTROL GRID VOLTAGE
Heptode anode voltage V_{ah} = 250Volts
Triode anode voltage V_{at} = 100Volts
Oscillator grid current I_{gt} = 200μA
Oscillator grid resistor R_{gt} = 47kΩ
g_c
r_c
SCREEN VOLTAGE V_{g2+g4}=100VOLTS
75
50
SCREEN SUPPLY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

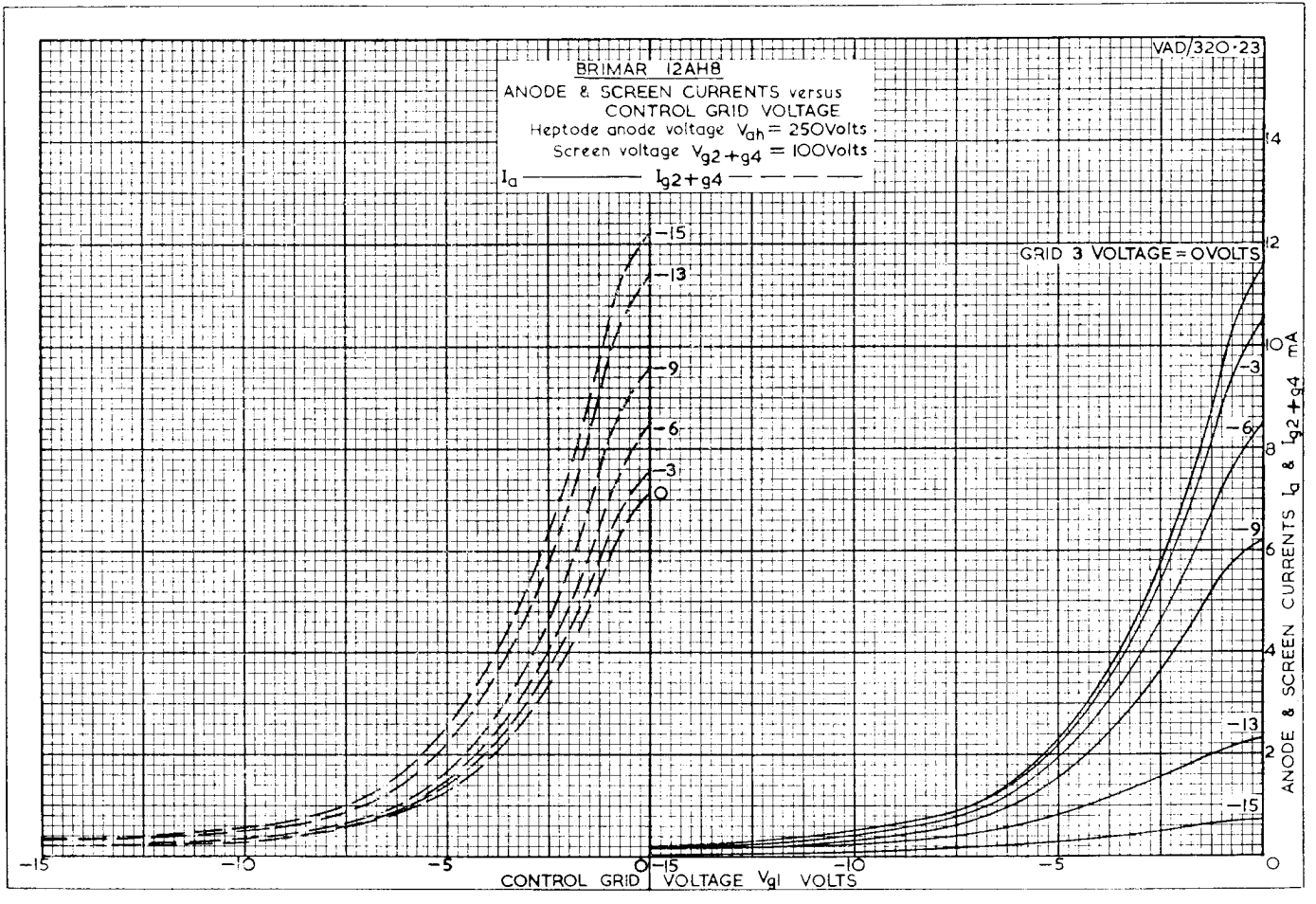

BRIMAR 12AH8
CONVERSION CONDUCTANCE & IMPEDANCE
versus OSCILLATOR GRID CURRENT
Heptode anode voltage V_{ah} = 100Volts
Control grid voltage V_{gl} = −3Volts
Triode anode voltage V_{at} = 100Volts
Oscillator grid resistor R_{gt} = 47kΩ
g_c ——— r_c — — — —
VAD/320-18
SCREEN VOLTAGE V_{g2+g4} = 100VOLTS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

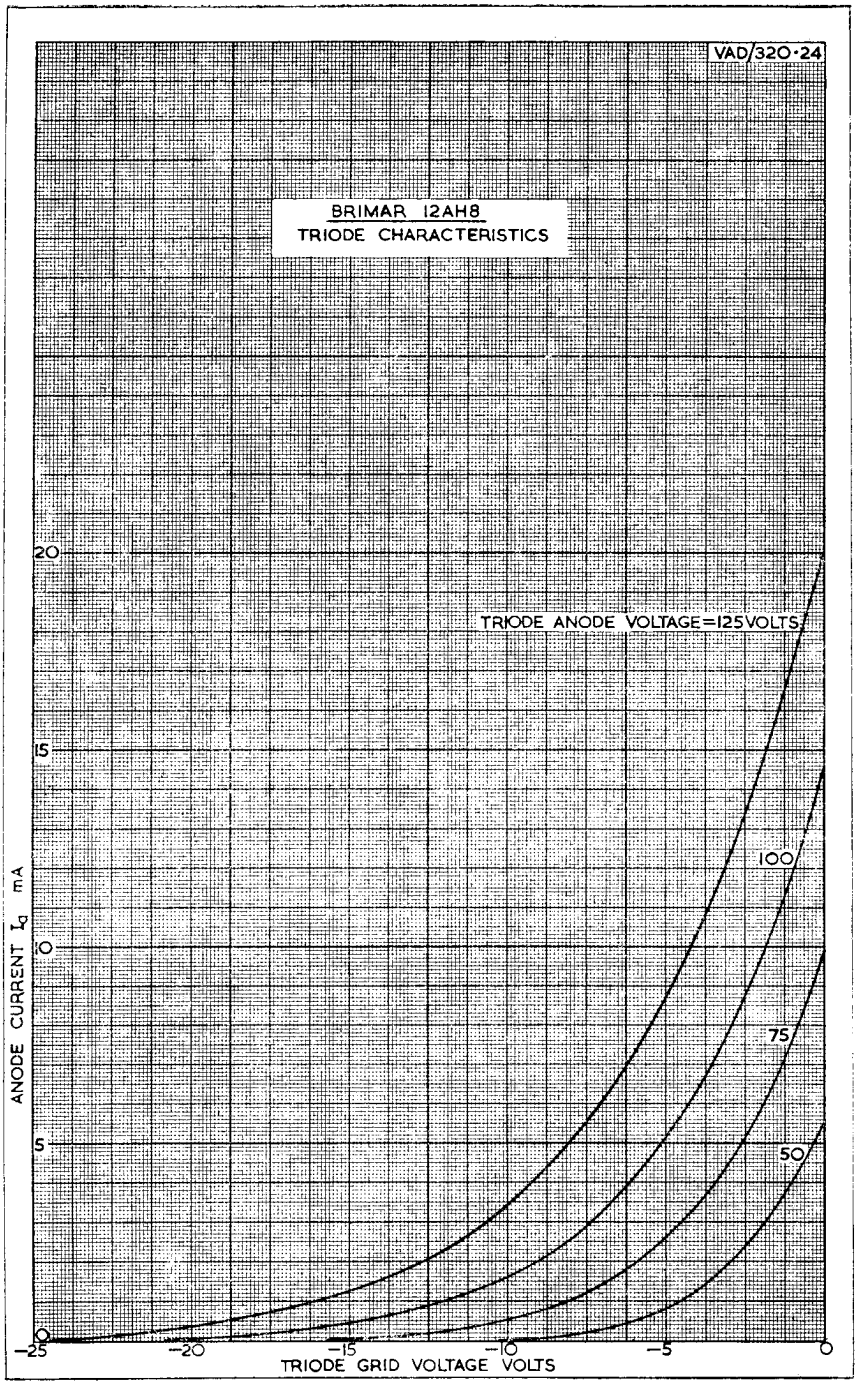

BRIMAR 12AH8
CONVERSION CONDUCTANCE & IMPEDANCE
versus OSCILLATOR GRID CURRENT
Heptode anode voltage V_{ah}=250Volts
Control grid voltage V_{gl} = —3Volts
Triode anode voltage V_{at}=100Volts
Oscillator grid resistor R_{gt}= 47kΩ
g_c ——— r_c — — — —
SCREEN SUPPLY VOLTAGE $V_{g2+g4(b)}$=250VOLTS
& SCREEN 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
1
2
3
4
5
6
200
400
600
50
100
150
200
250
300

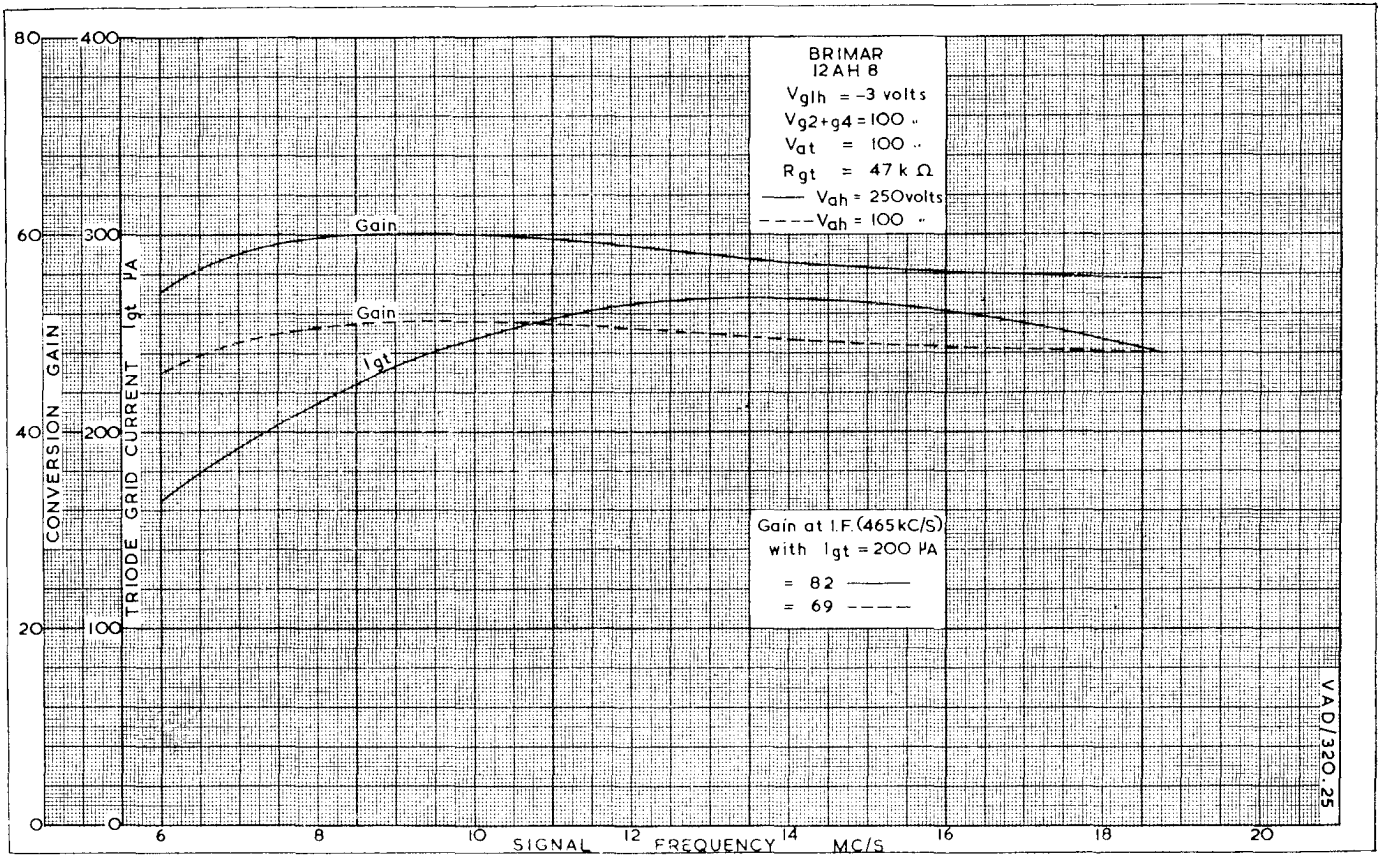

BRIMAR 12AH8
ANODE & SCREEN CURRENTS versus
OSCILLATOR GRID CURRENT
Heptode anode voltage V_{ah} = 100Volts
Control grid voltage V_{g1} = −3Volts
Triode anode voltage V_{at} = 100Volts
Oscillator grid resistor R_{gt} = 47kΩ
I_a ——— I_{g2+g4} – – – –
VAD/320-20
SCREEN VOLTAGE V_{g2+g4} = 100VOLTS
100V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

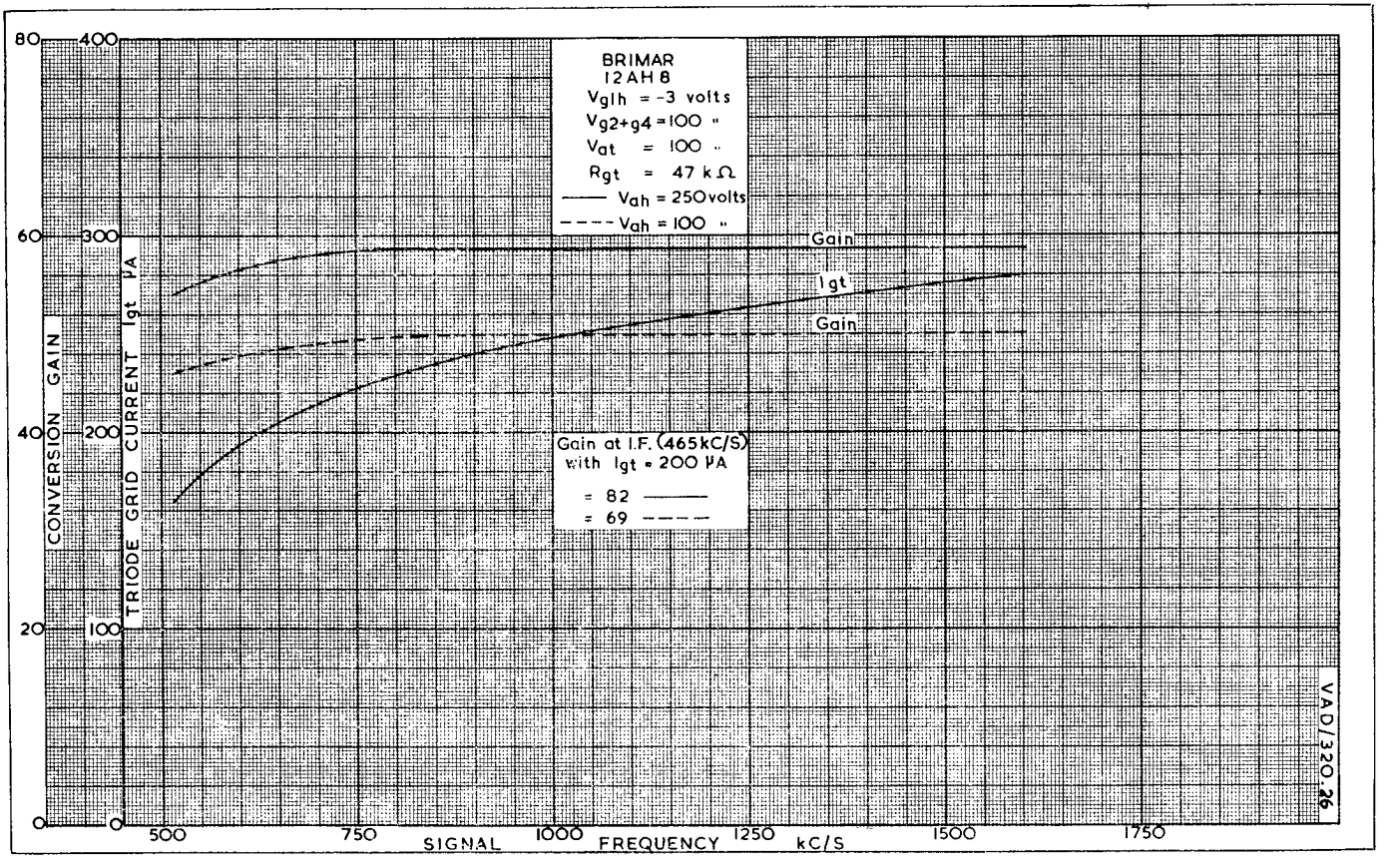

BRIMAR 12AH8
ANODE & SCREEN CURRENTS versus
OSCILLATOR GRID CURRENT
Heptode anode voltage V_{ah} = 250Volts
Control grid voltage V_{g1} = −3Volts
Triode anode voltage V_{at} = 100Volts
Oscillator grid resistor R_{gt} = 47kΩ
I_a ——— I_{g2+g4} — — — —
VAD/320-21
SCREEN SUPPLY VOLTAGE $V_{g2+g4(b)}$ = 250VOLTS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

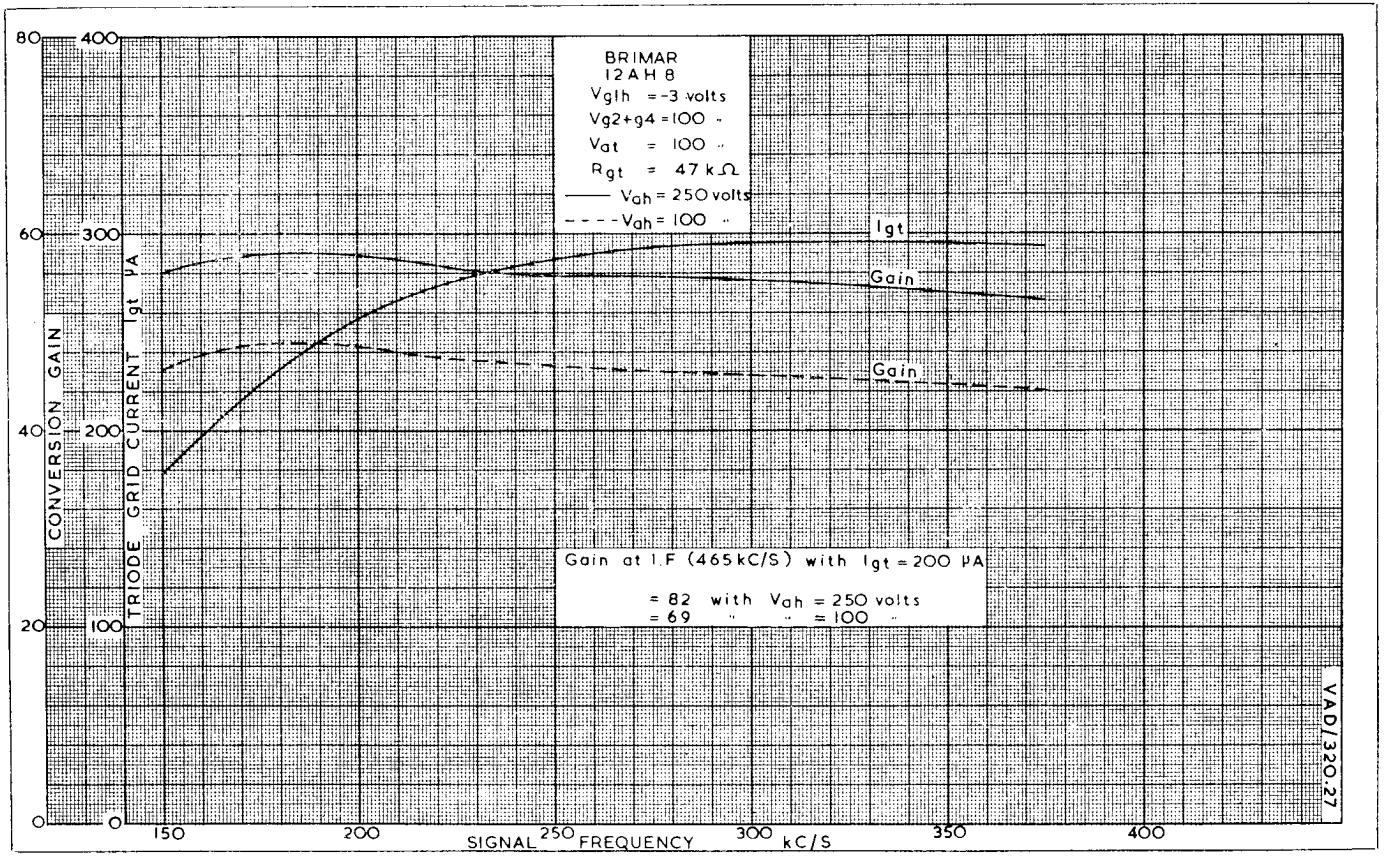

VAD/320·22
BRIMAR 12AH8
ANODE & SCREEN CURRENTS versus
GRID 3 VOLTAGE
Heptode anode voltage V_{ah} = 250Volts
Screen voltage V_{g2+g4} = 100Volts
I_a ——— I_{g2+g4} — — — —
CONTROL GRID VOLTAGE=0VOLTS
0
-1
-2
-3
-4
-5
-7·5
-15
-10
-5
0
14
12
10
8
6
4
2
0
ANODE & SCREEN CURRENTS I_a & I_{g2+g4} mA
GRID 3 VOLTAGE VOLTS

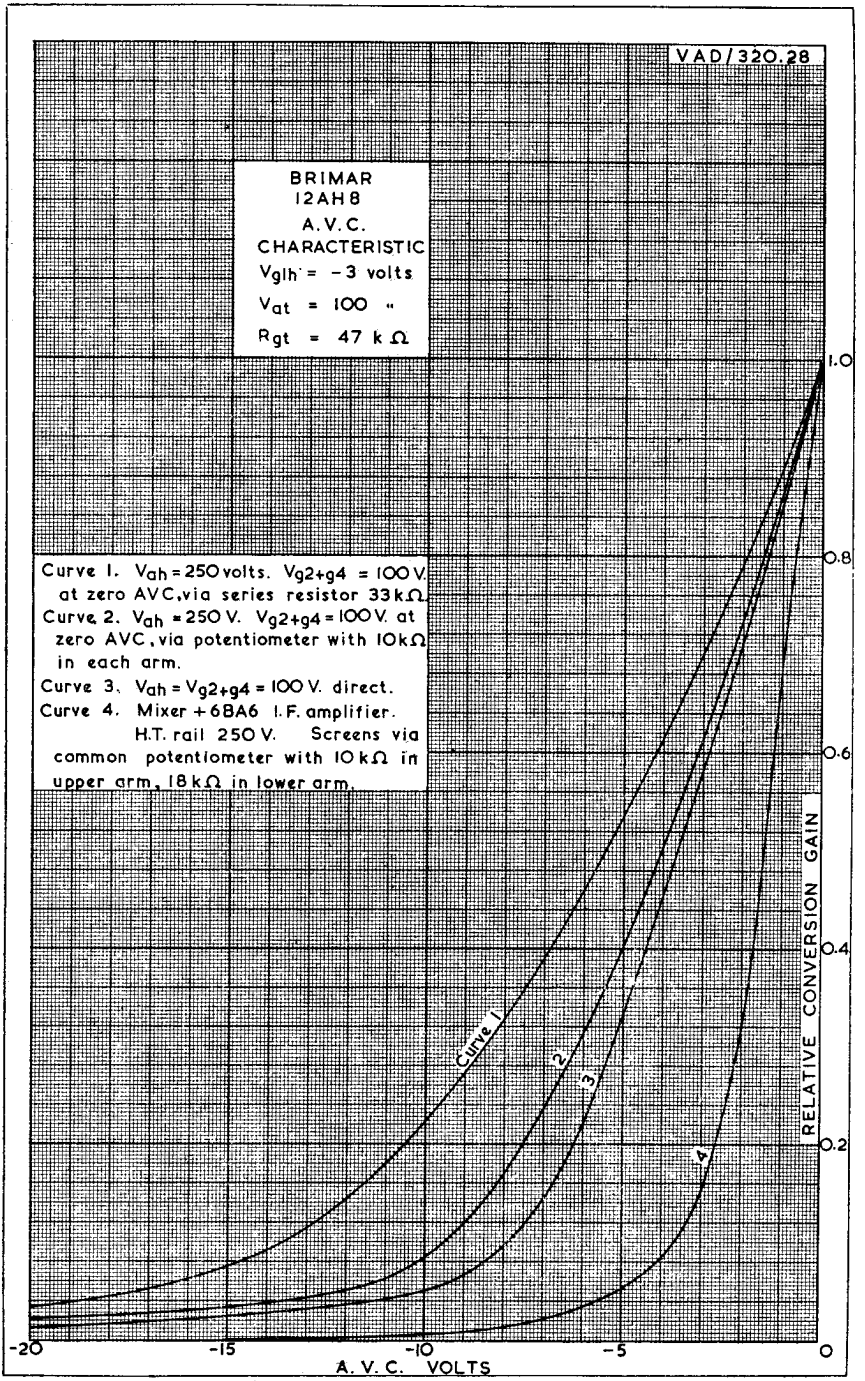

VAD/320·23
BRIMAR 12AH8
ANODE & SCREEN CURRENTS versus
CONTROL GRID VOLTAGE
Heptode anode voltage V_{ah} = 250Volts
Screen voltage V_{g2+g4} = 100Volts
I_a ——— I_{g2+g4} — — — —
GRID 3 VOLTAGE = 0VOLTS
-15
-13
-9
-6
-3
0
-3
-6
-9
-13
-15
14
12
10
8
6
4
2
0
ANODE & SCREEN CURRENTS I_a & I_{g2+g4} mA
-15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

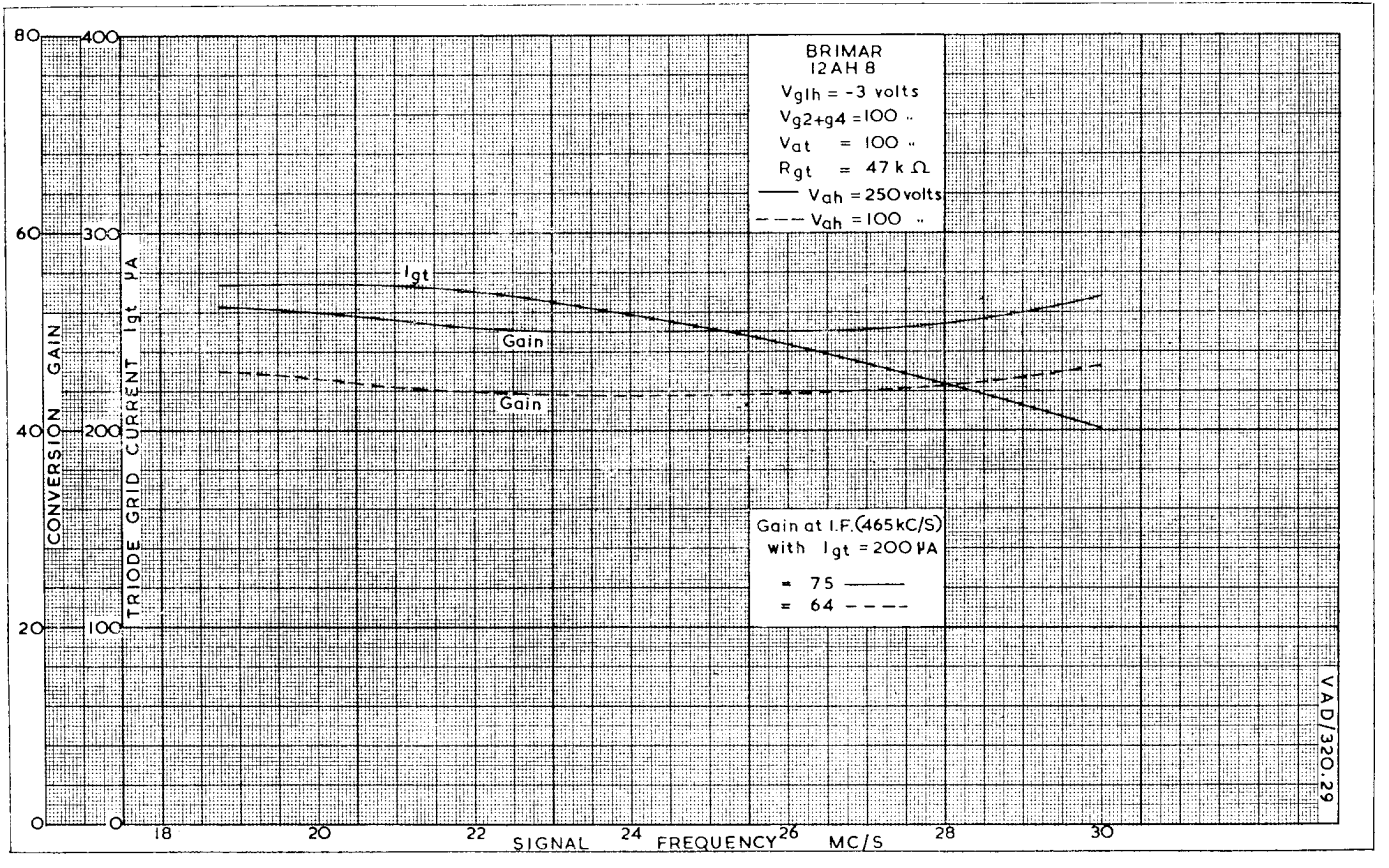

VAD/320·24
BRIMAR 12AH8
TRIODE CHARACTERISTICS
TRIODE ANODE VOLTAGE=125VOLTS
100
75
50
20
15
10
5
0
ANODE CURRENT I_a mA
−25
−20
−15
−10
−5
0
TRIODE GRID VOLTAGE VOLTS

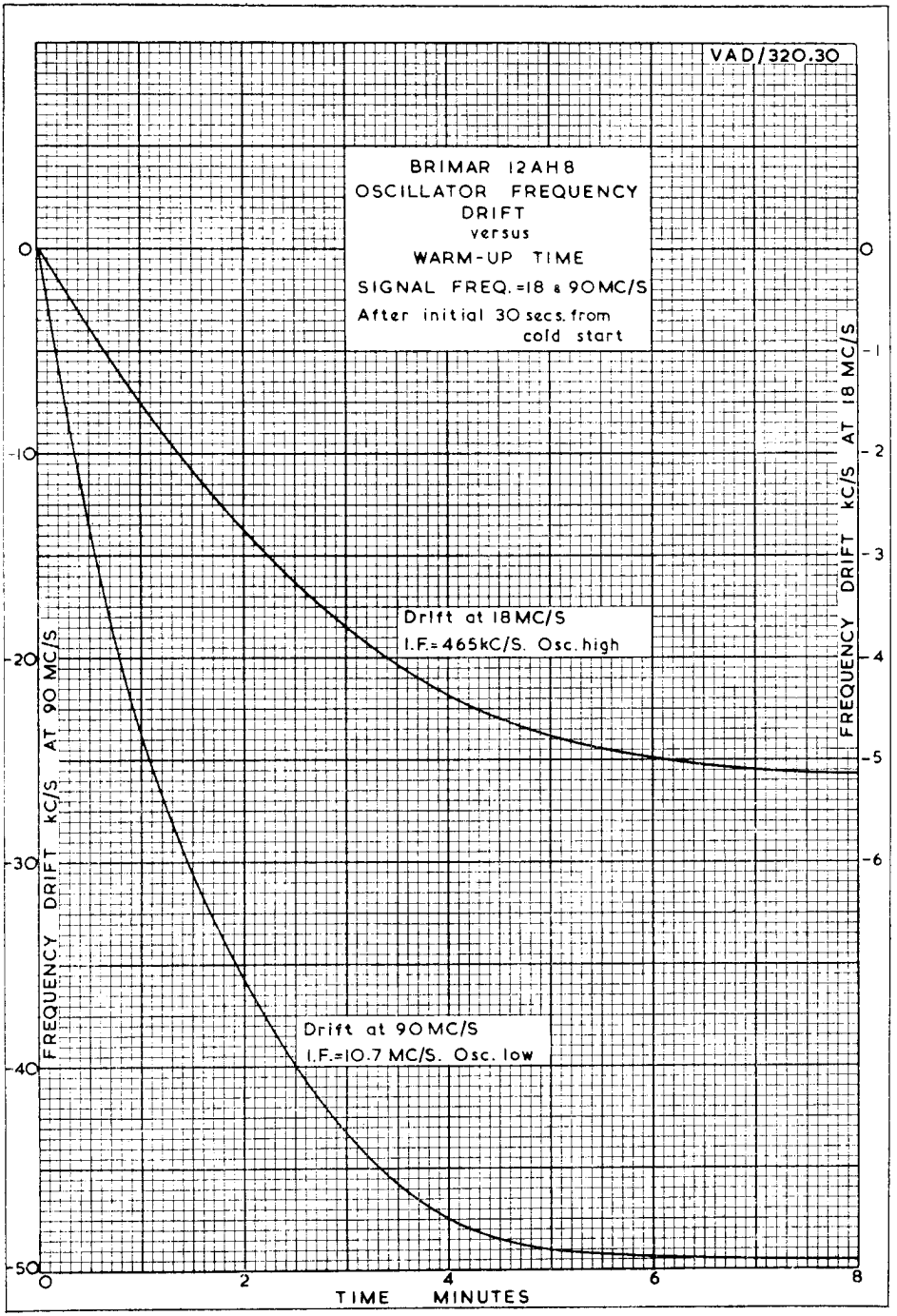

BRIMAR
12AH8
V_{glh} = −3 volts
V_{g2+g4} = 100 "
V_{at} = 100 "
R_{gt} = 47 kΩ
—— V_{ah} = 250volts
- - - - V_{ah} = 100 "
Gain
Gain
I_{gt}
Gain at I.F.(465kC/S)
with I_{gt} = 200 μA
= 82 ——
= 69 - - - -
CONVERSION GAIN
TRIODE GRID CURRENT I_{gt} μA
SIGNAL FREQUENCY MC/S
0
20
40
60
80
100
200
300
400
6
8
10
12
14
16
18
20
VAD/320.25

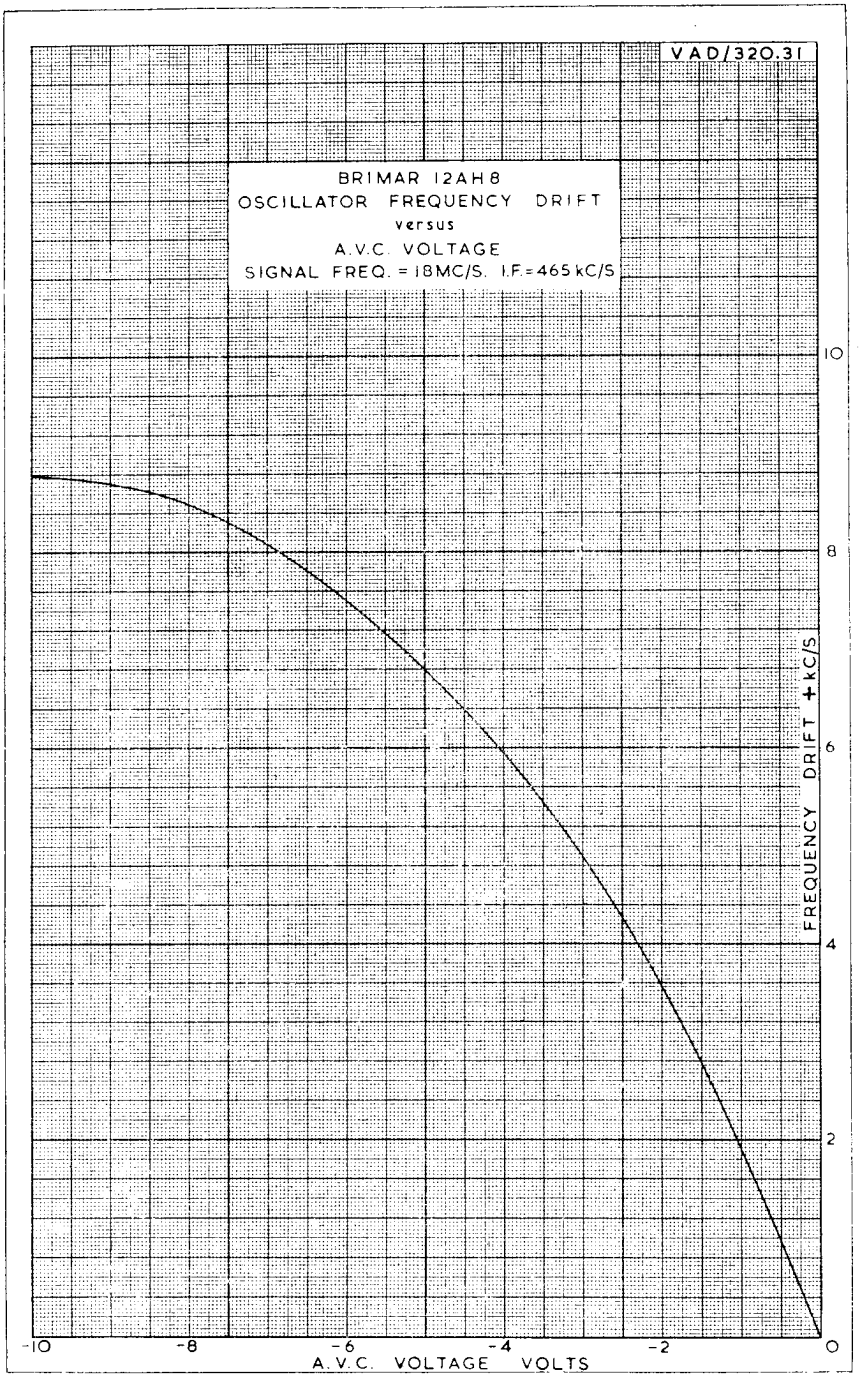

BRIMAR
12AH8
Vg1h = -3 volts
Vg2+g4 = 100 "
Vat = 100 "
Rgt = 47 kΩ
—— Vah = 250 volts
- - - - Vah = 100 "
Gain
Igt
Gain
Gain at I.F. (465kC/S)
with Igt = 200 μA
= 82 ——
= 69 - - - -
CONVERSION GAIN
TRIODE GRID CURRENT Igt μA
SIGNAL FREQUENCY kC/S
80
60
40
20
0
400
300
200
100
0
500
750
1000
1250
1500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

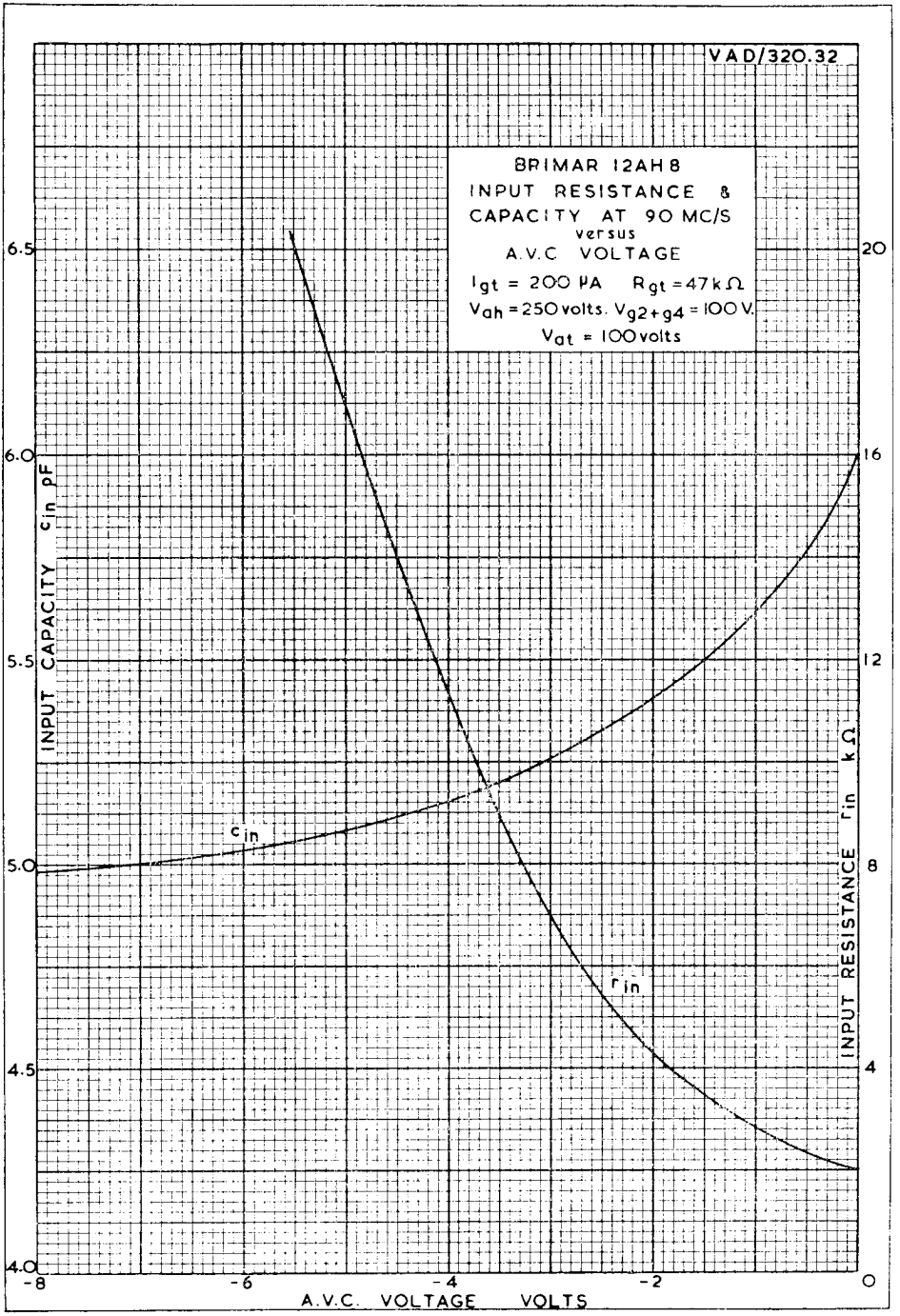

BRIMAR
12AH8
Vg1h = -3 volts
Vg2+g4 = 100 "
Vat = 100 "
Rgt = 47 kΩ
Vah = 250 volts
Vah = 100 "
Igt
Gain
Gain
Gain at I.F (465 kC/S) with Igt = 200 μA
= 82 with Vah = 250 volts
= 69 " " = 100 "
CONVERSION GAIN
TRIODE GRID CURRENT Igt μA
SIGNAL FREQUENCY kC/S
VAD/320.27
0
20
40
60
80
100
200
300
400
150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


VAD/320.28
BRIMAR
12AH8
A.V.C.
CHARACTERISTIC
Vglh = −3 volts
Vat = 100 "
Rgt = 47 kΩ
Curve 1. Vah = 250 volts. Vg2+g4 = 100 V. at zero AVC, via series resistor 33 kΩ.
Curve 2. Vah = 250 V. Vg2+g4 = 100 V. at zero AVC, via potentiometer with 10 kΩ in each arm.
Curve 3. Vah = Vg2+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.
RELATIVE CONVERSION GAIN
1.0
0.8
0.6
0.4
0.2
Curve 1
2
3
4
-20
-15
-10
-5
0
A. V. C. VOLTS


BRIMAR
12AH8
V_{glh} = -3 volts
V_{g2+g4} = 100 ..
V_{at} = 100 ..
R_{gt} = 47 kΩ
—— V_{ah} = 250 volts
– – – V_{ah} = 100 ..
Gain at I.F. (465 kC/S)
with I_{gt} = 200 μA
= 75 ——
= 64 – – – –
I_{gt}
Gain
Gain
CONVERSION GAIN
TRIODE GRID CURRENT I_{gt} μA
SIGNAL FREQUENCY MC/S
0
20
40
60
80
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.=10.7 MC/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
A.V.C. VOLTAGE VOLTS
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