

BRIMAR

RECEIVING VALVE 6AM6

APPLICATION REPORT VAD/508.2

The document is the property of S. T. & C. Ltd. It is a condition that it is not to be reproduced, in whole or in part, without the consent in writing of S. T. & C. Ltd.

The publication of information in this document does not imply freedom from patent rights of S. T. & C. Ltd. or others, nor is any responsibility or liability assumed or accepted.

The right is reserved to make such modifications to the data herein without publication.

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

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_s and Shield	
	Pin 7 Screen Grid g_a	

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.

GROUNDING 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 biased 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 $I_{g2} 165 \mu\text{A}$, hence the cathode resistor will be $\frac{0.9 \times 1000}{0.7 + 0.165}$ or 1000 ohms. The screen

dropping resistor would be $\frac{250 - 60}{0.165 \times 1000}$ 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 $\frac{46}{0.1}$ 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.

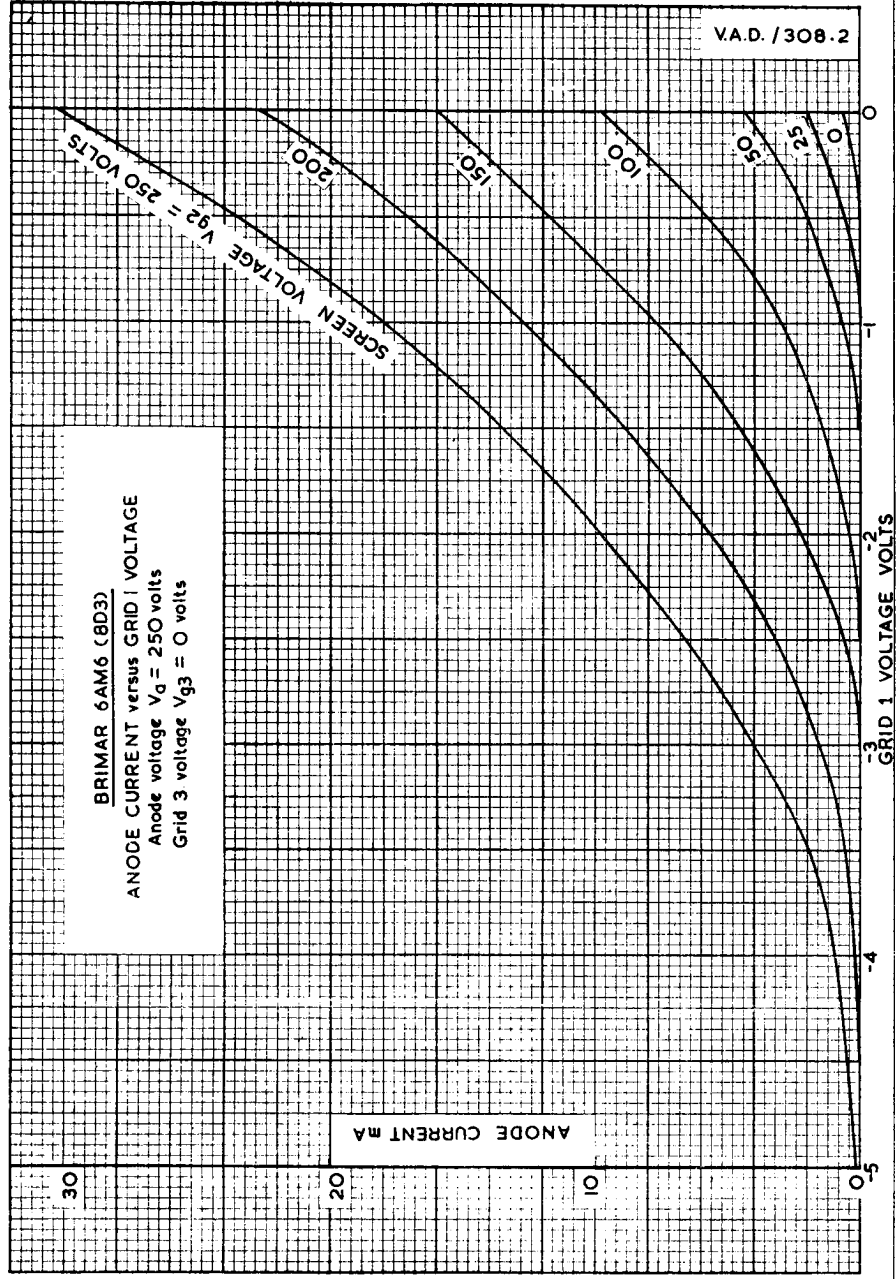
Curve No. 308-207 shows the voltage gain with three values of capacity 10, 15 and 20 pF for a load of 2-2K; Curves Nos. 308-208, 308-209 and 308-210 show corresponding curves for loads of 3-3, 4-7 and 6-8K. In the case of the latter the response cannot be compensated for a capacity of greater than 15 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 (8D32)
ANODE CURRENT versus GRID 1 VOLTAGE
Anode voltage $V_a = 250$ volts
Grid 3 voltage $V_{g3} = 0$ volts



V.A.D. / 308.3

BRIMAR 6AM6 (8D3)

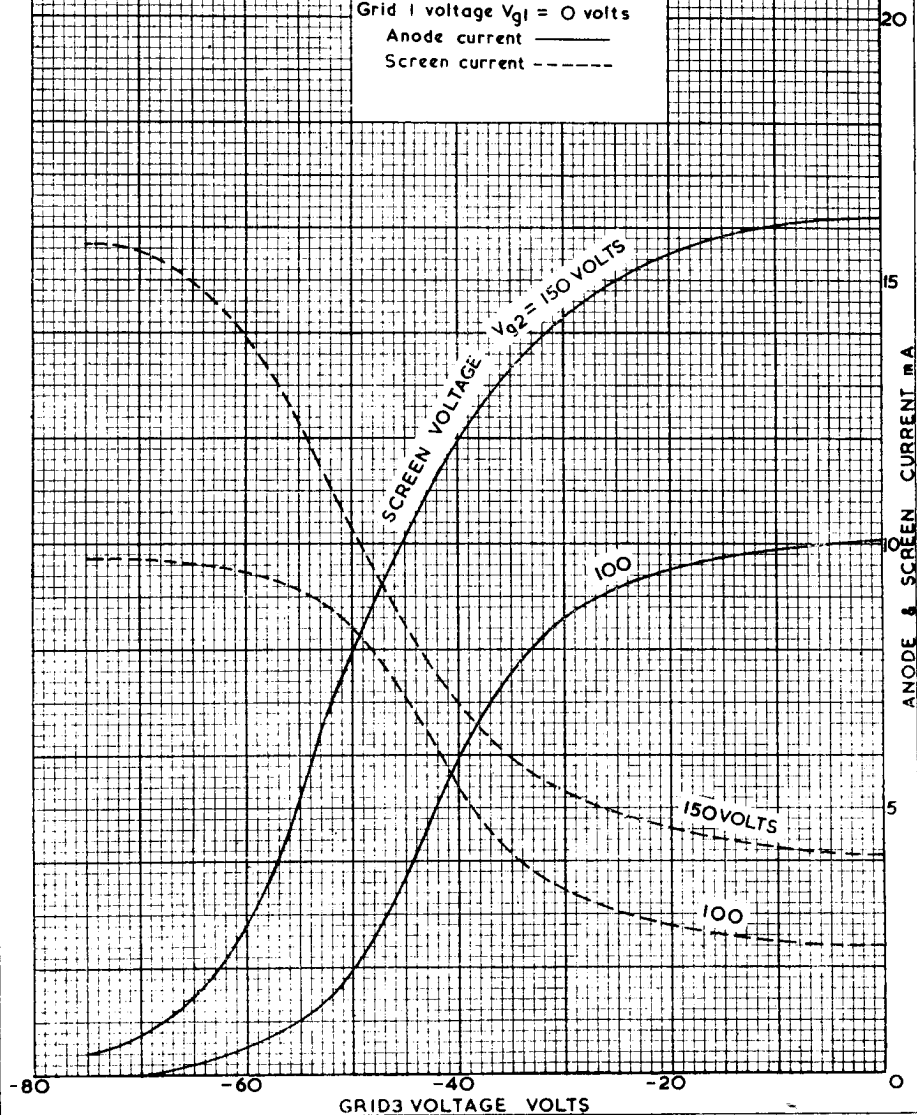
**ANODE & SCREEN CURRENT
versus GRID 3 VOLTAGE**

Anode voltage $V_a = 300$ volts

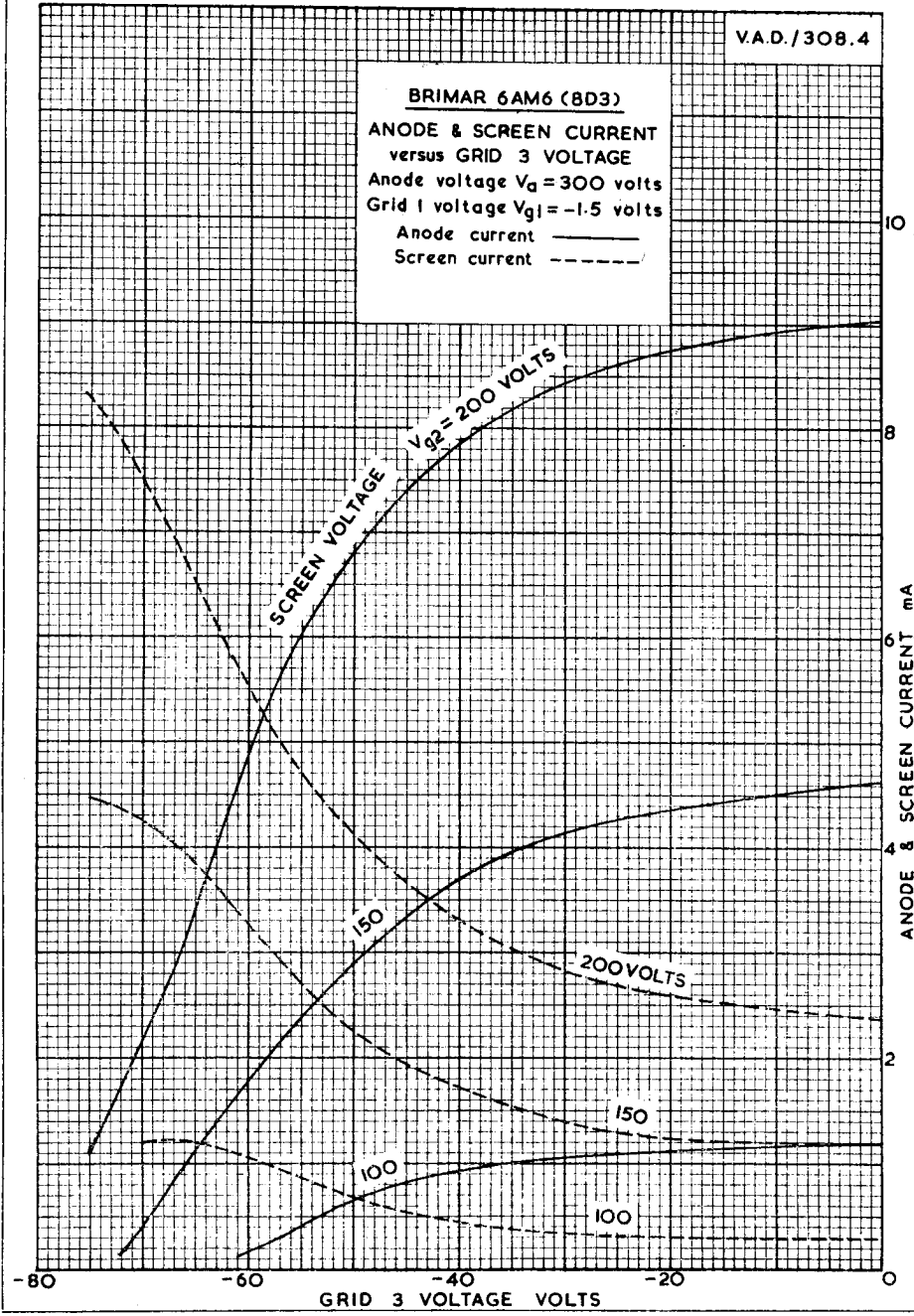
Grid 1 voltage $V_{g1} = 0$ volts

Anode current ———

Screen current - - - - -



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 - - - - -



BRIMAR 6AM6 (8D3)

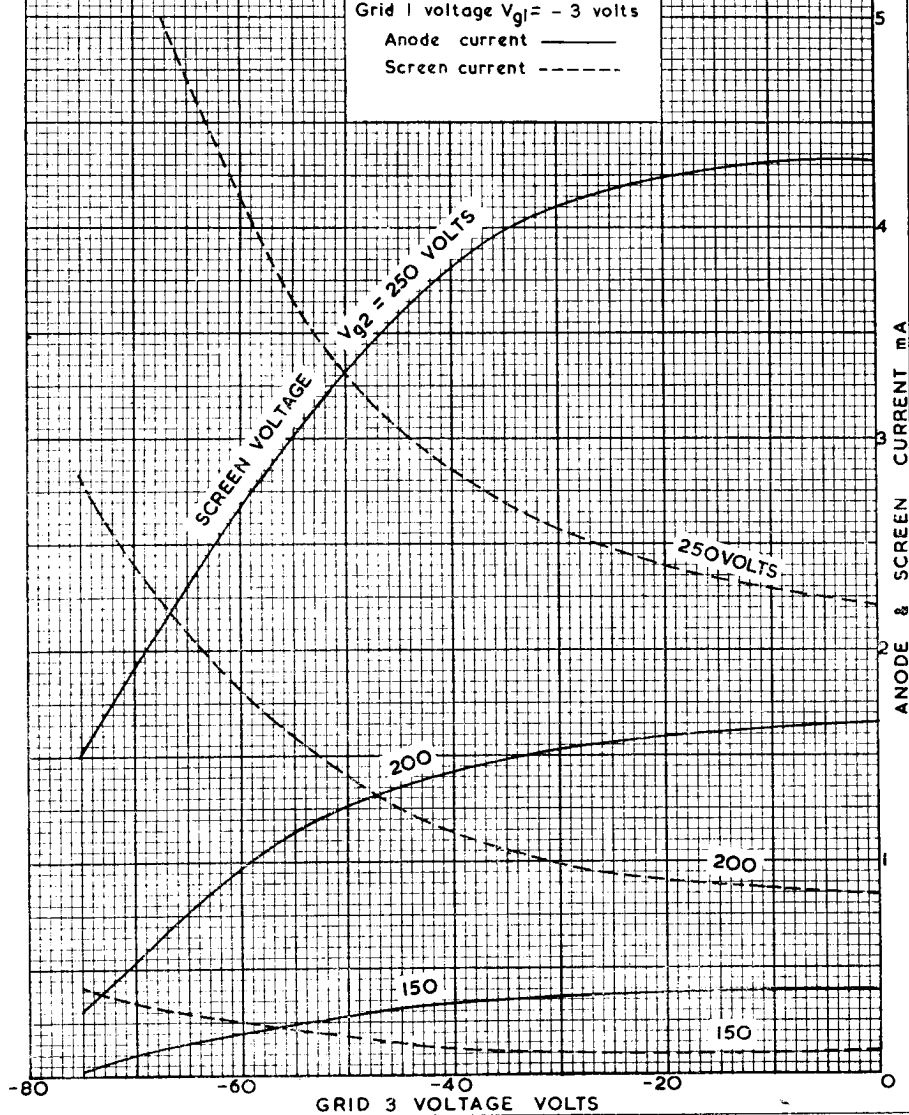
ANODE & SCREEN CURRENT
versus GRID 3 VOLTAGE

Anode voltage $V_a = 300$ volts

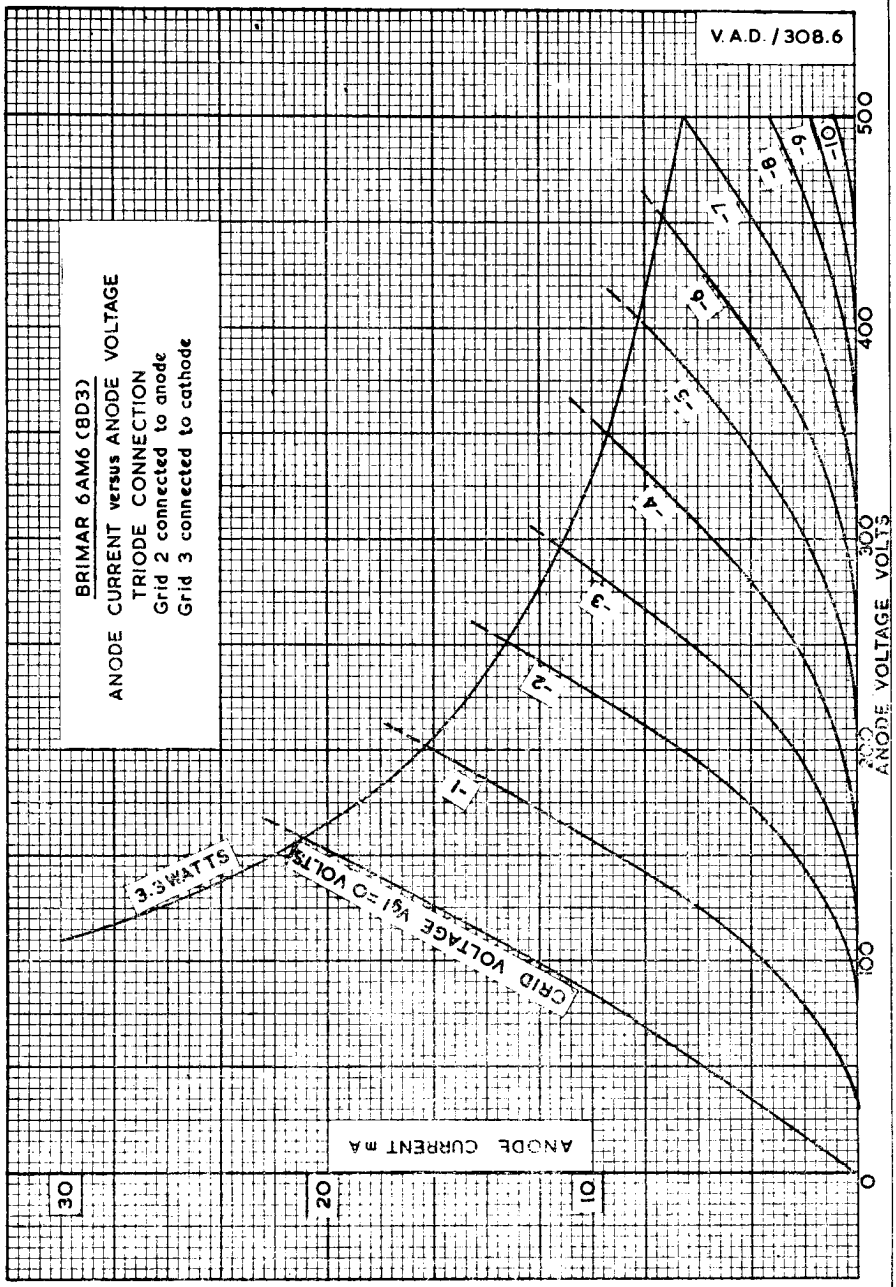
Grid 1 voltage $V_{g1} = -3$ volts

Anode current ———

Screen current - - - - -



BRIMAR 6AM6 (BD3)
ANODE CURRENT versus ANODE VOLTAGE
TRIODE CONNECTION
Grid 2 connected to anode
Grid 3 connected to cathode



30

20

10

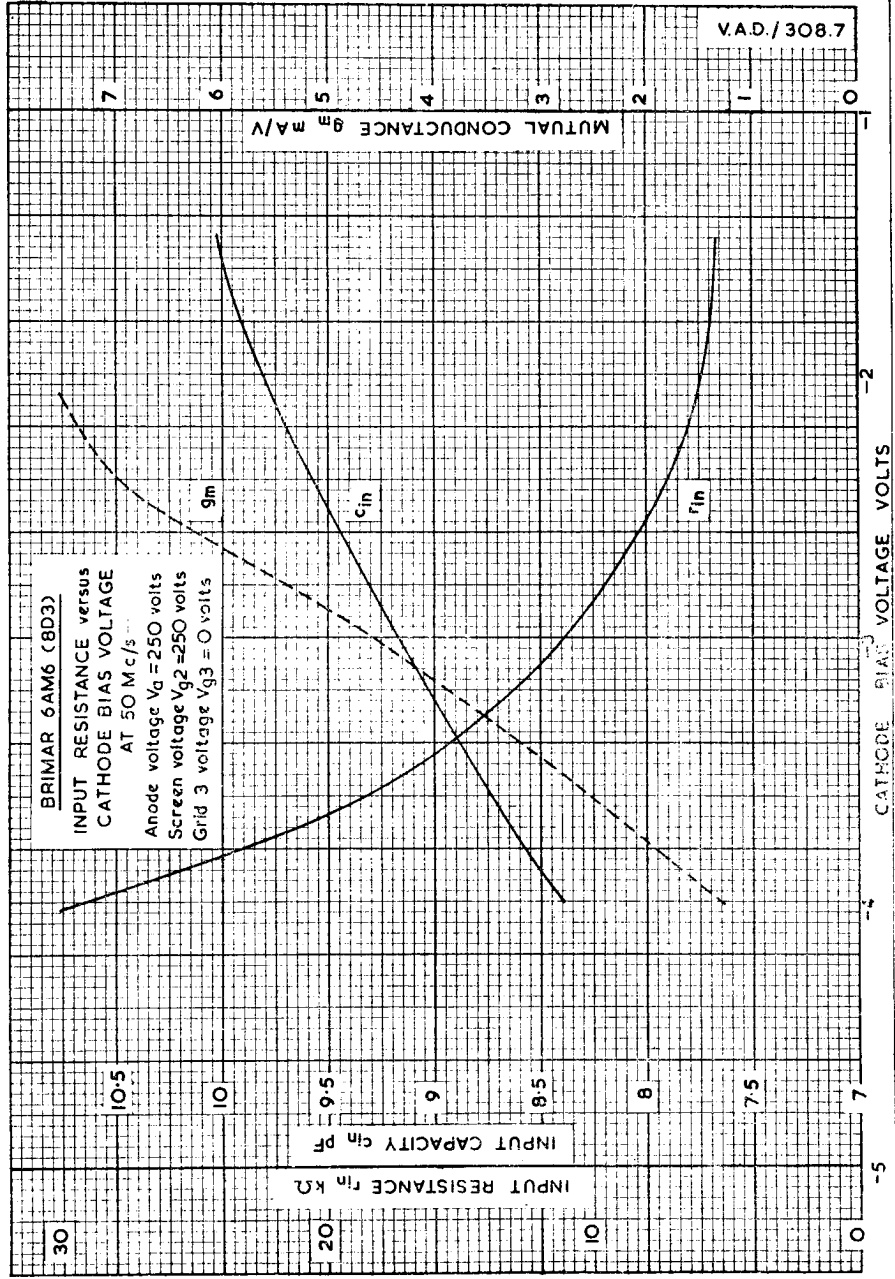
0

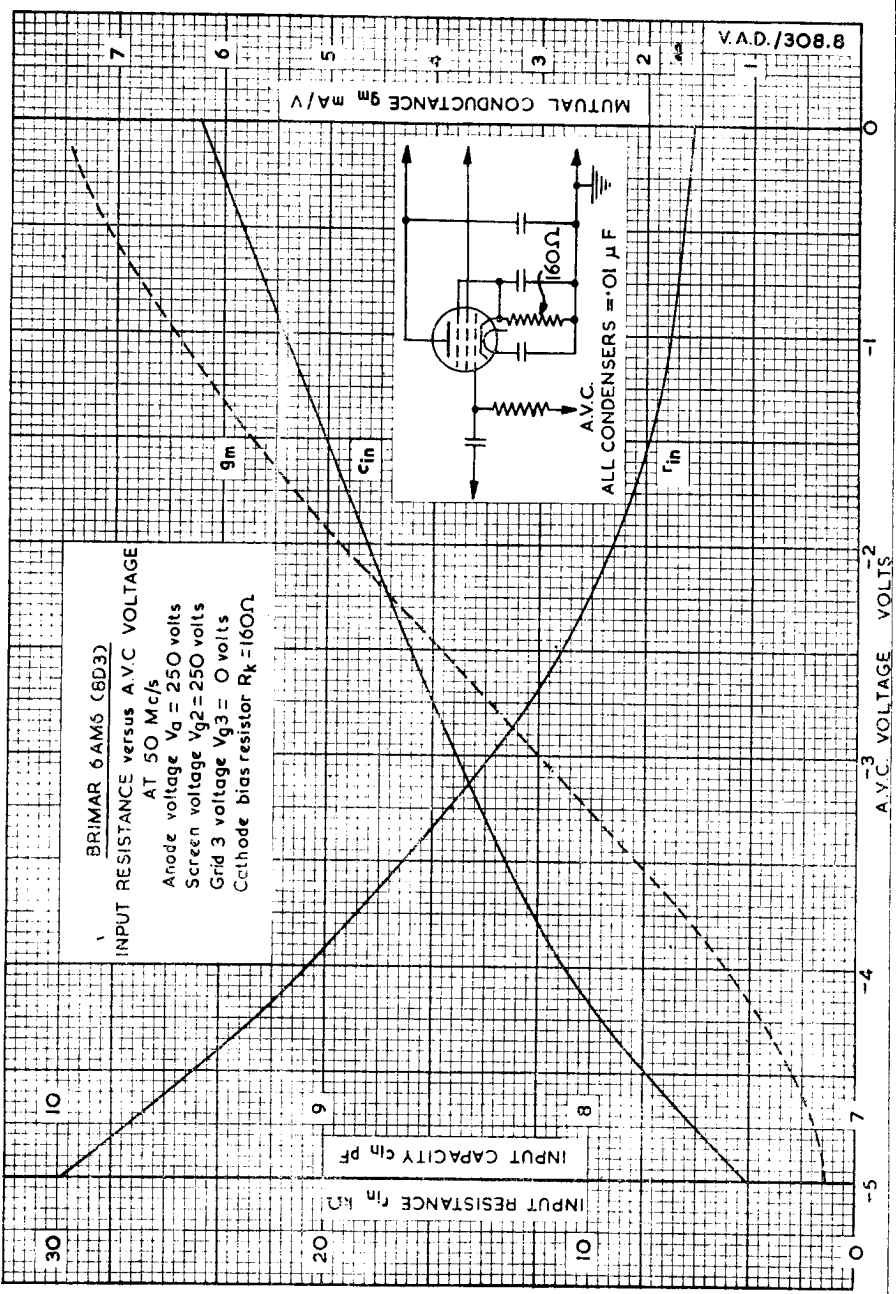
ANODE CURRENT mA

ANODE VOLTAGE VOLTS

3.5 WATTS

GRID VOLTAGE Vg1 = 0 VOLTS





BRIMAR 6AM6 (8D3)

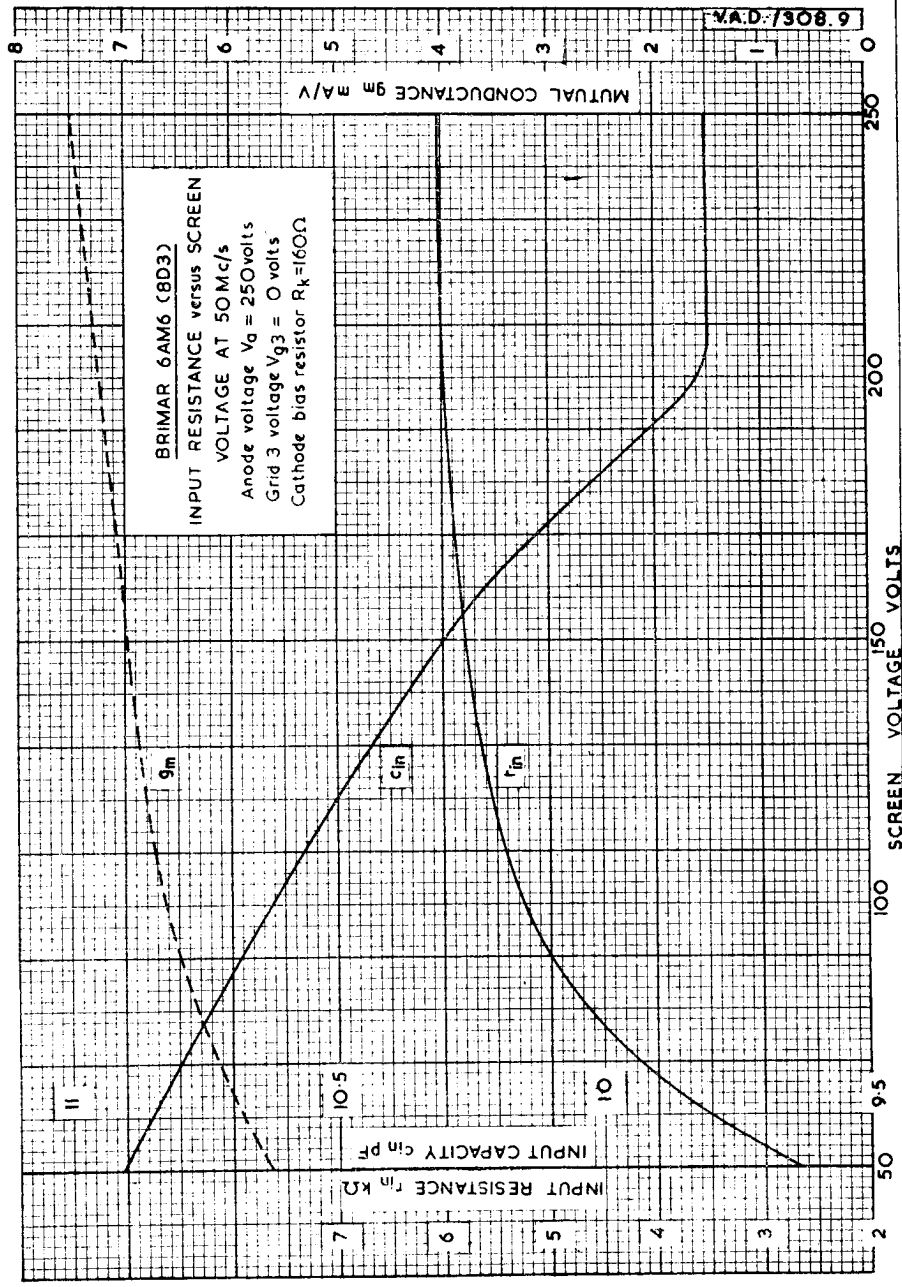
INPUT RESISTANCE versus SCREEN

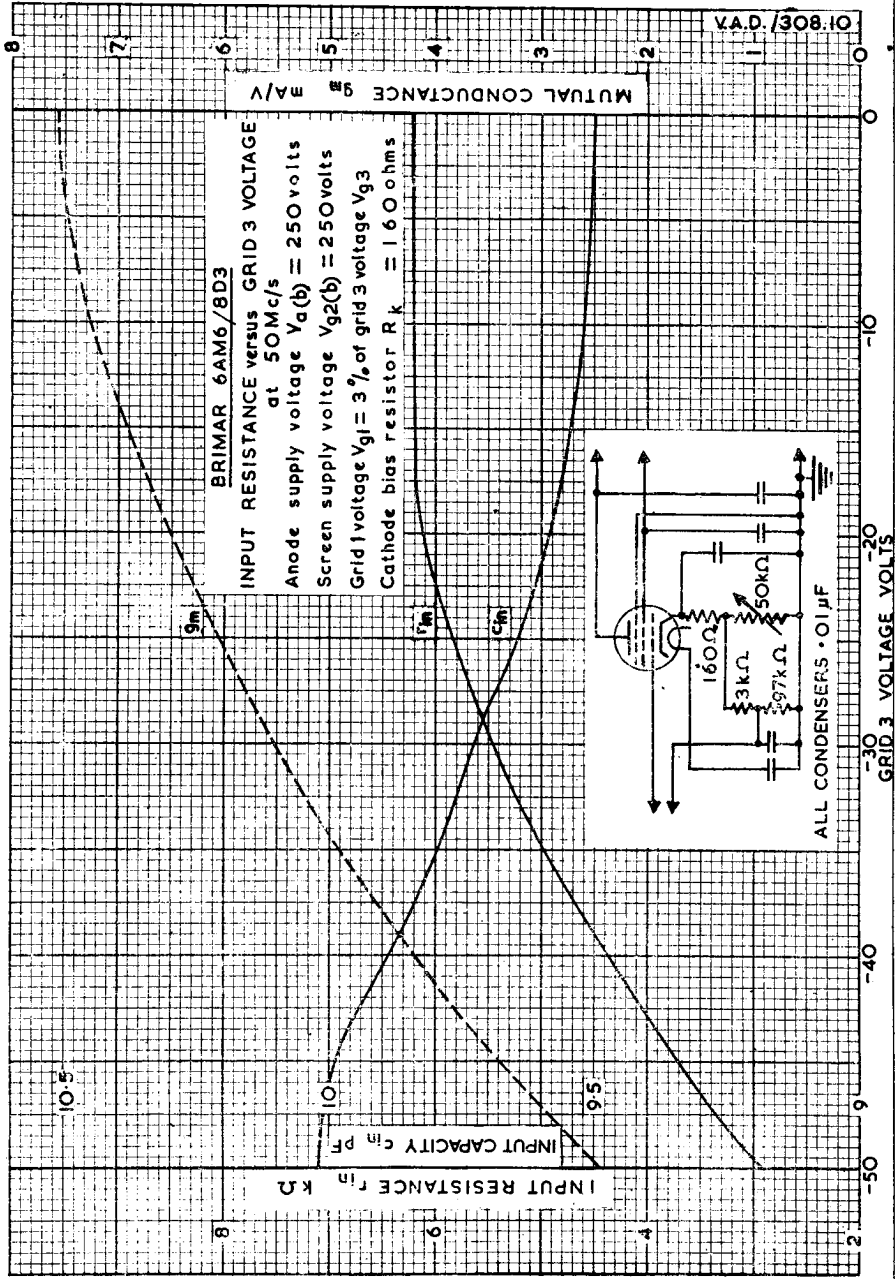
VOLTAGE AT 50 Mc/s

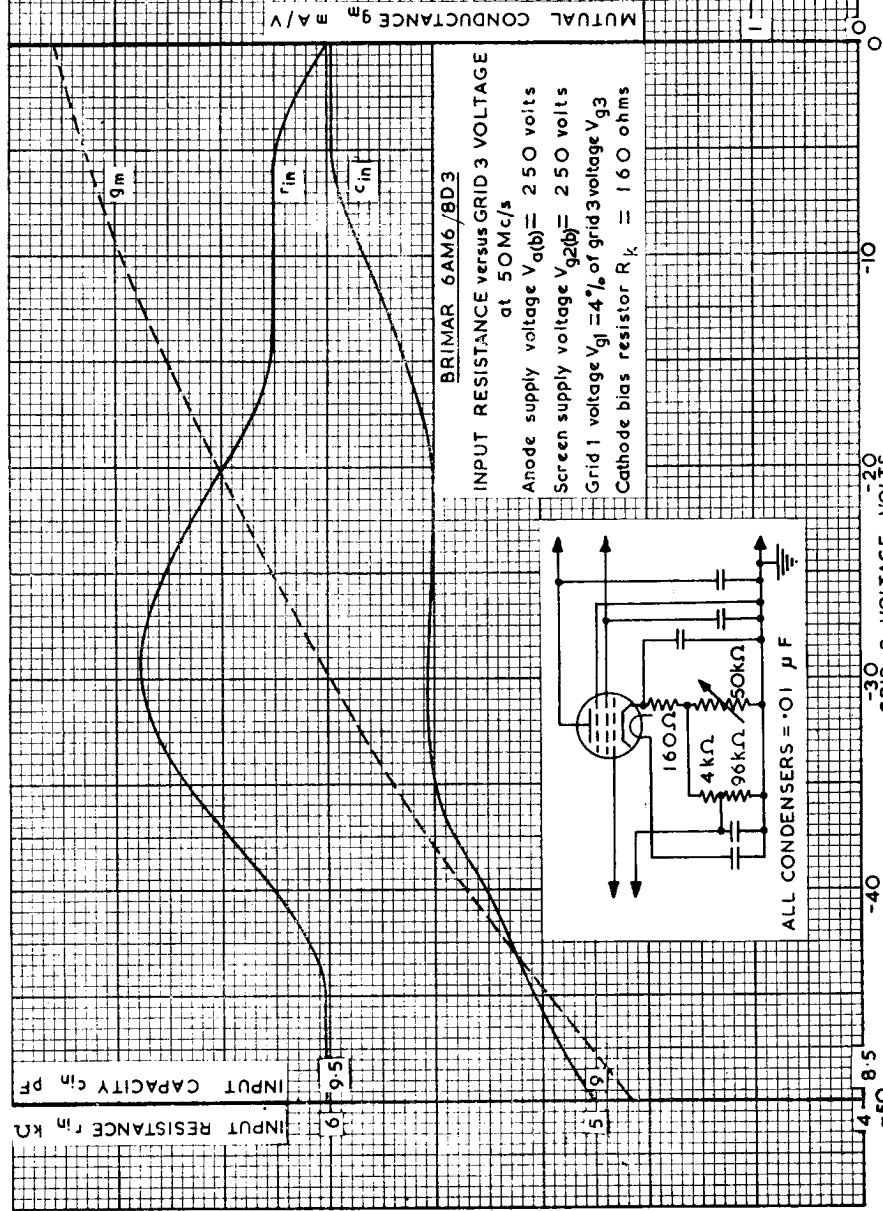
Anode voltage $V_a = 250$ volts

Grid 3 voltage $V_{g3} = 0$ volts

Cathode bias resistor $R_k = 160\Omega$

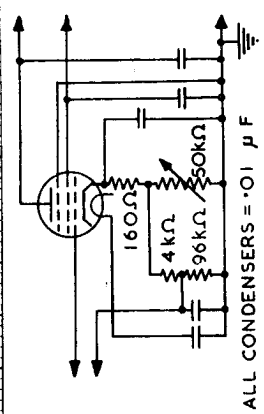






BRIMAR 6AM6/BD3

INPUT RESISTANCE versus GRID 3 VOLTAGE
 at 50 Mc/s
 Anode supply voltage $V_{a(b)} = 250$ volts
 Screen supply voltage $V_{s2(b)} = 250$ volts
 Grid 1 voltage $V_{g1} = 4\%$ of grid 3 voltage V_{g3}
 Cathode bias resistor $R_k = 160$ ohms



ALL CONDENSERS = 0.01 μ F

INPUT RESISTANCE r_{in} kΩ
 INPUT CAPACITY c_{in} pF

MUTUAL CONDUCTANCE g_m A/V

GRID 3 VOLTAGE VOLTS

BRIMAR 6AM6/BD3

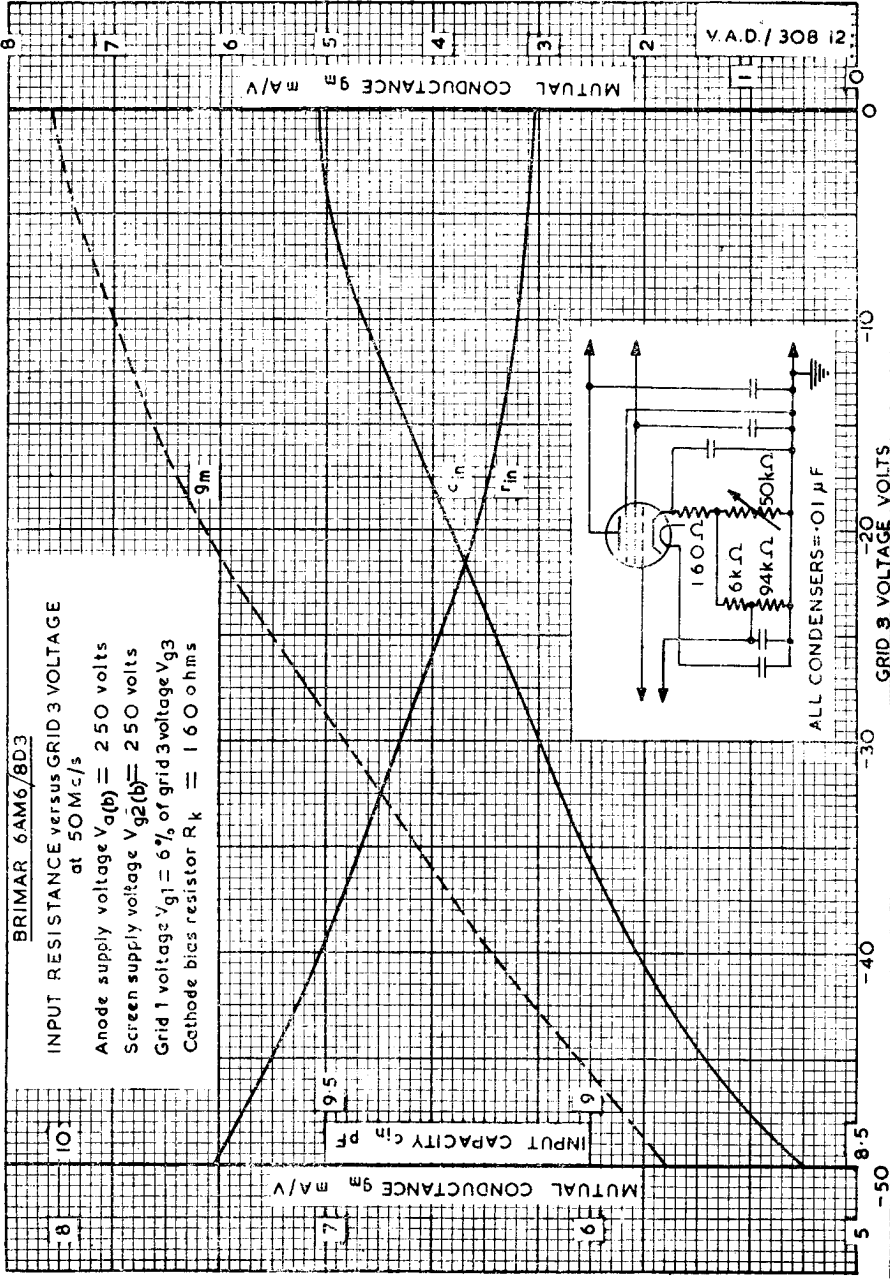
INPUT RESISTANCE versus GRID 3 VOLTAGE
at 50 Mc/s

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



V.A.D. / 308 12

MUTUAL CONDUCTANCE g_m mA/V

MUTUAL CONDUCTANCE g_m mA/V

INPUT CAPACITY c_{in} pF

GRID 3 VOLTAGE VOLTS

ALL CONDENSERS = 0.01 μ F

BRIMAR 6AM6 (8D3)

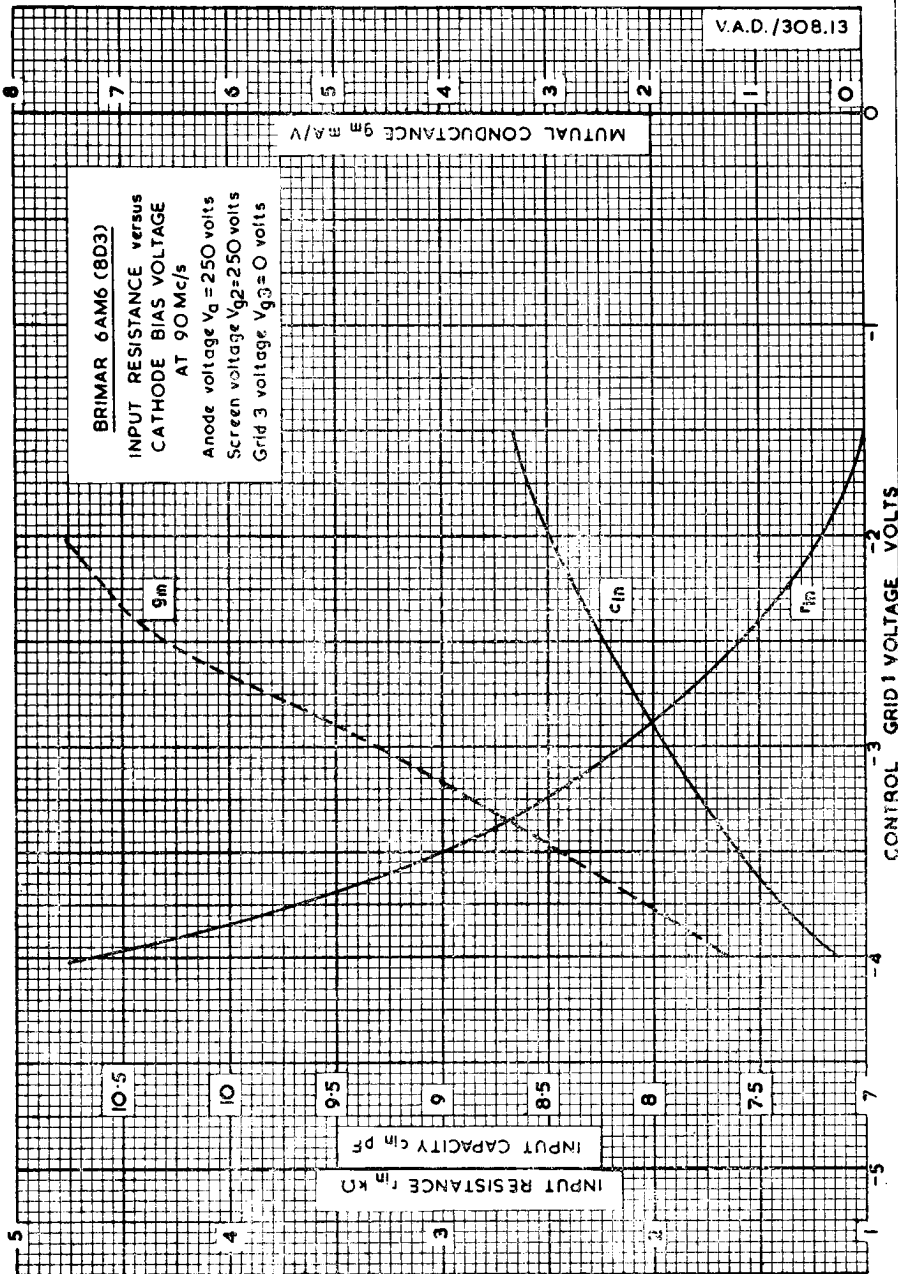
**INPUT RESISTANCE versus
CATHODE BIAS VOLTAGE**

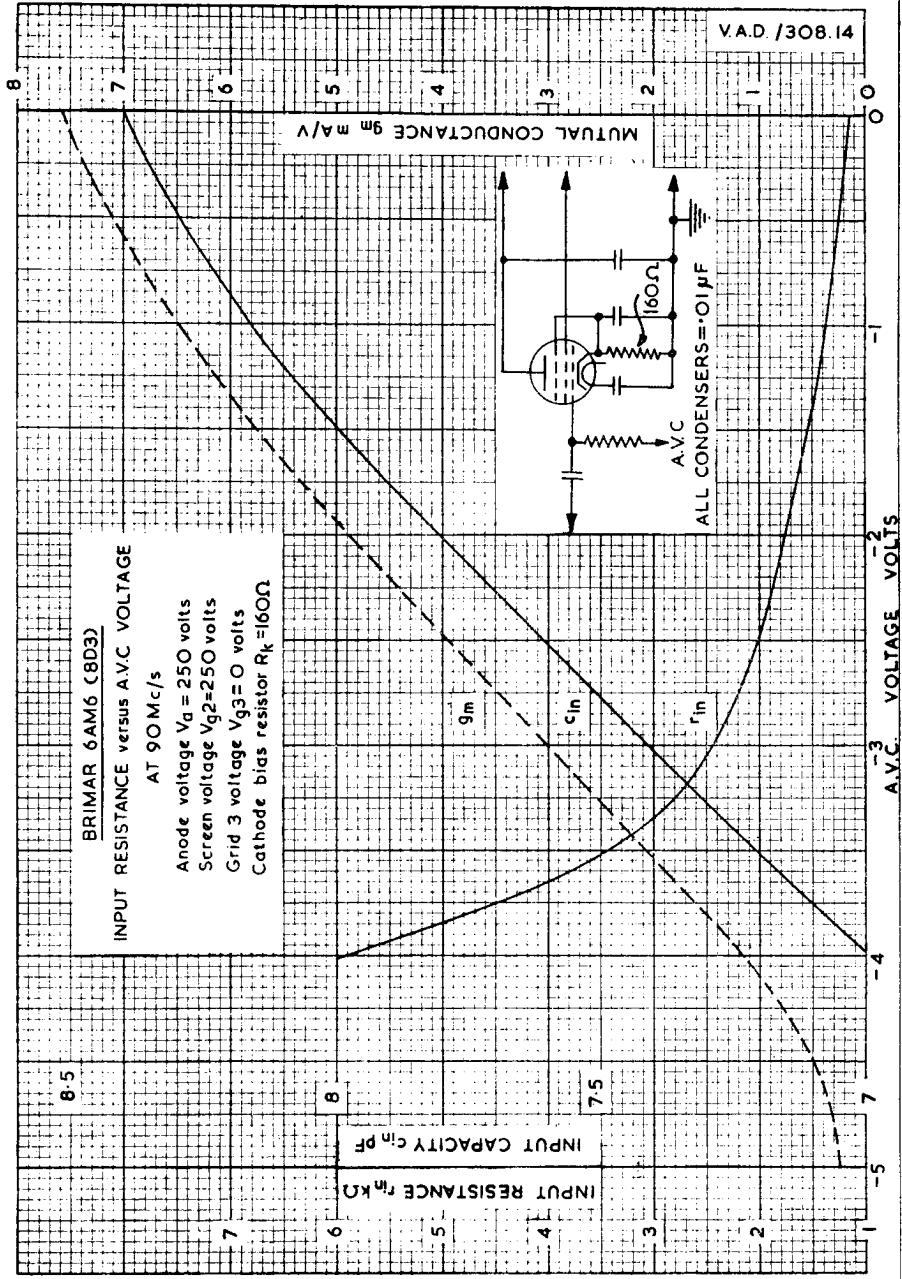
AT 90 Mc/s

Anode voltage $V_a = 250$ volts

Screen voltage $V_{g2} = 250$ volts

Grid 3 voltage $V_{g3} = 0$ volts





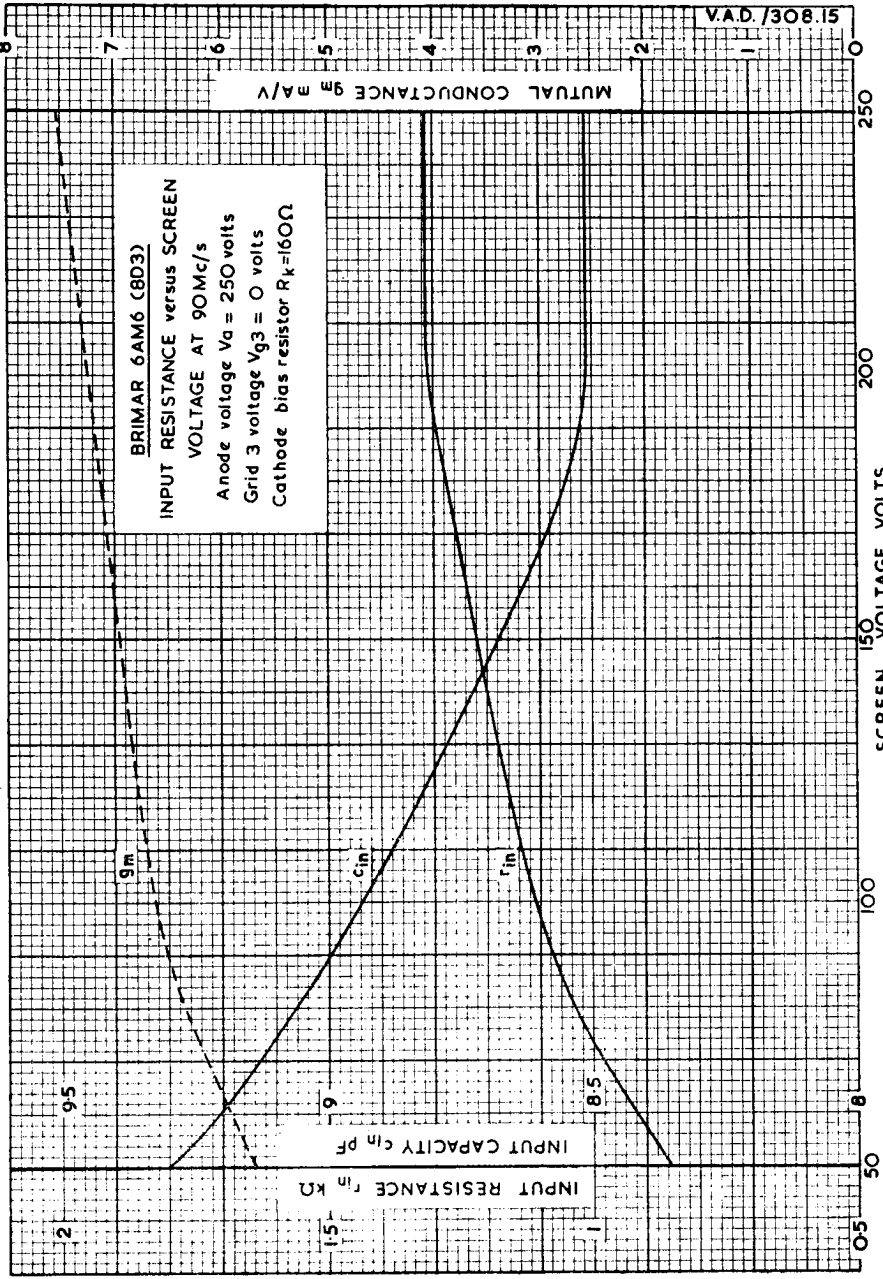
BRIMAR 6AM6 (8D3)
INPUT RESISTANCE versus A.V.C. VOLTAGE
 AT 90 Mc/s
 Anode voltage $V_a = 250$ volts
 Screen voltage $V_{g2} = 250$ volts
 Grid 3 voltage $V_{g3} = 0$ volts
 Cathode bias resistor $R_k = 160\Omega$

8.5

INPUT RESISTANCE r_{in} k Ω
 INPUT CAPACITY C_{in} pF

MUTUAL CONDUCTANCE g_m mA/V

A.V.C. VOLTAGE VOLTS



BRIMAR 6AM6 (8D3)
INPUT RESISTANCE versus SCREEN VOLTAGE AT 90Mc/s
Anode voltage $V_a = 250$ volts
Grid 3 voltage $V_{g3} = 0$ volts
Cathode bias resistor $R_k = 60\Omega$

2

INPUT RESISTANCE r_s k Ω

INPUT CAPACITY c_p pF

9.5

g_m

c_{in}

r_m

0.5

50

100

150

200

250

0

MUTUAL CONDUCTANCE g_m mA/V

SCREEN VOLTAGE VOLTS

8

7

6

5

4

3

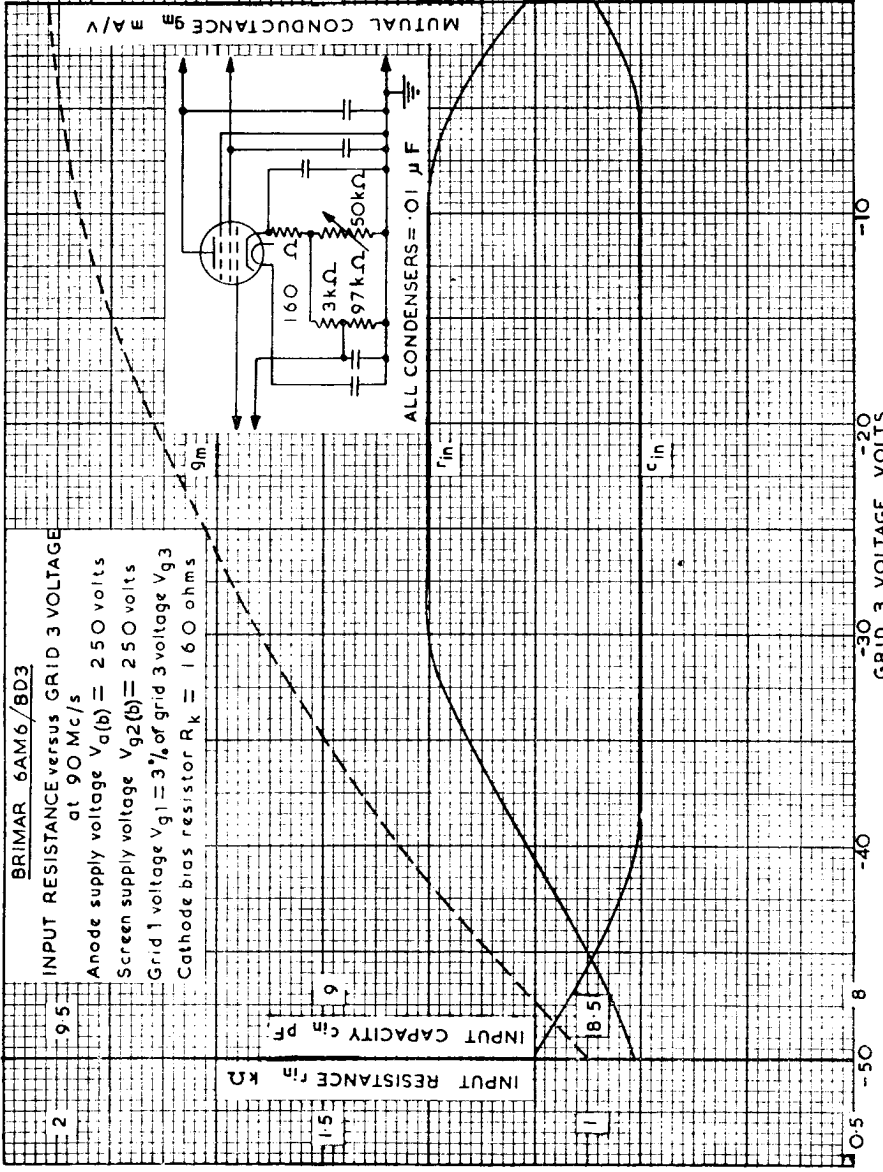
2

1

0

BRIMAR 6AM6/BD3

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



BRIMAR 6AM6 / BD3

INPUT RESISTANCE versus GRID 3 VOLTAGE

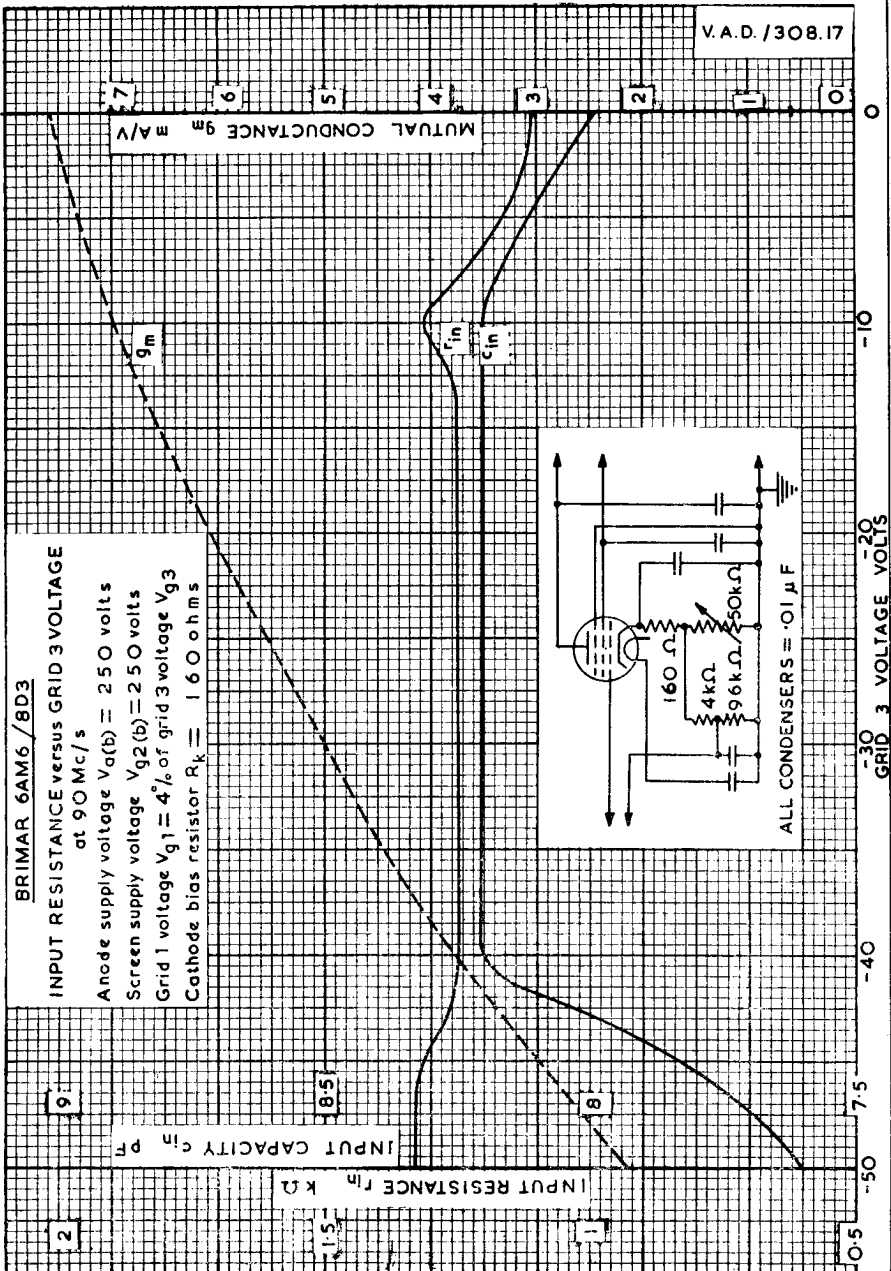
at 90 Mc/s

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}

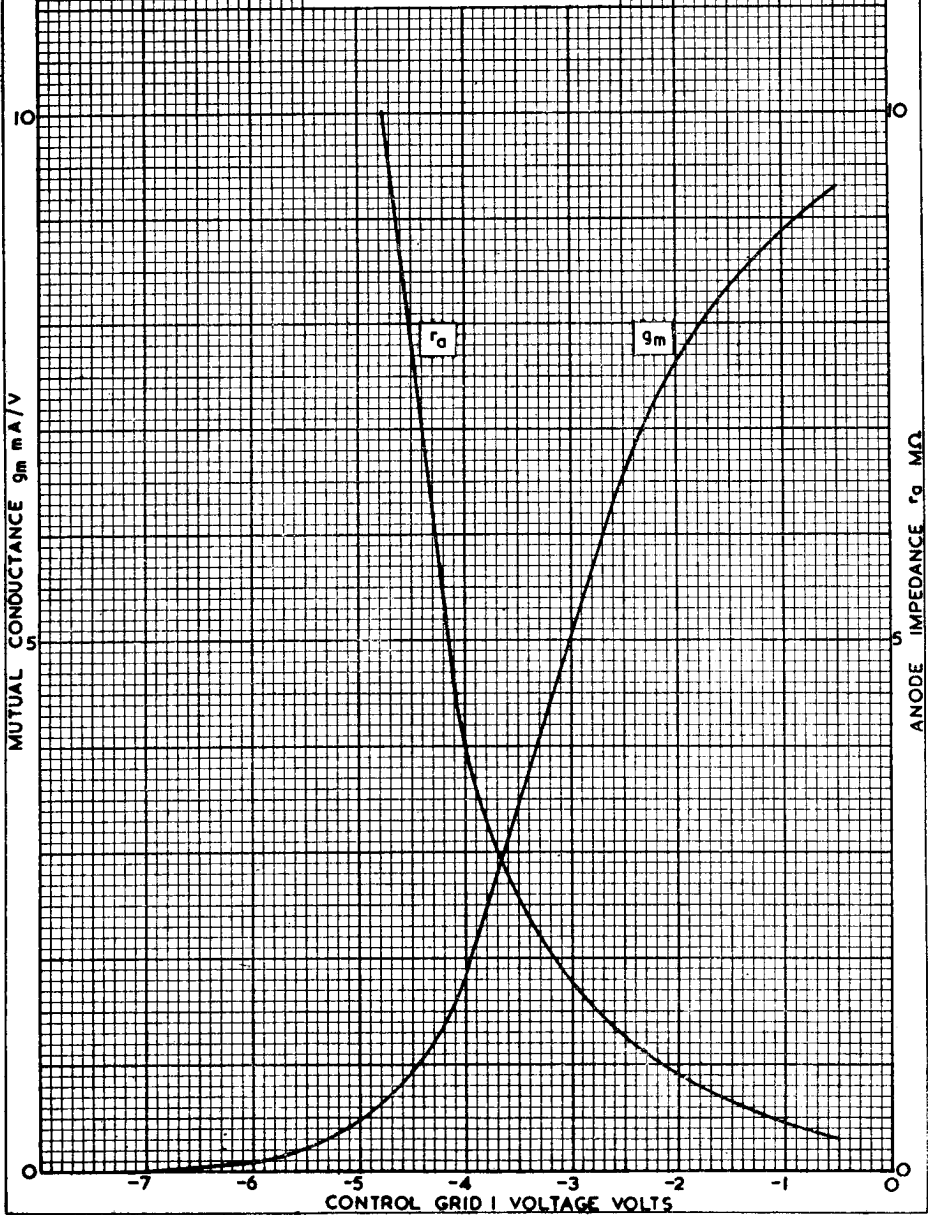
Cathode bias resistor $R_k = 160$ ohms



BRIMAR 6AM6/8D3

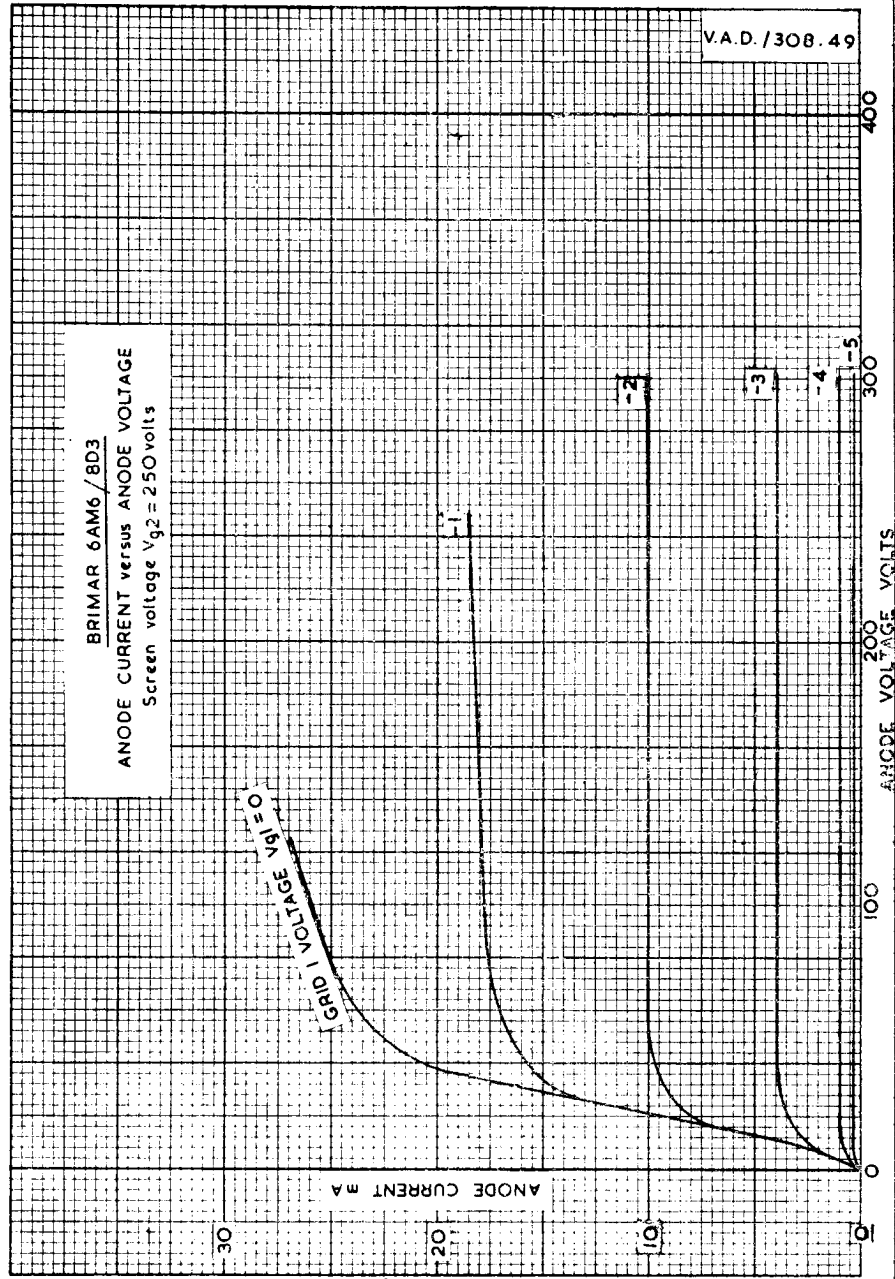
V.A.D./308 48

Anode voltage $V_a = 250$ volts
Screen voltage $V_{g2} = 250$ volts

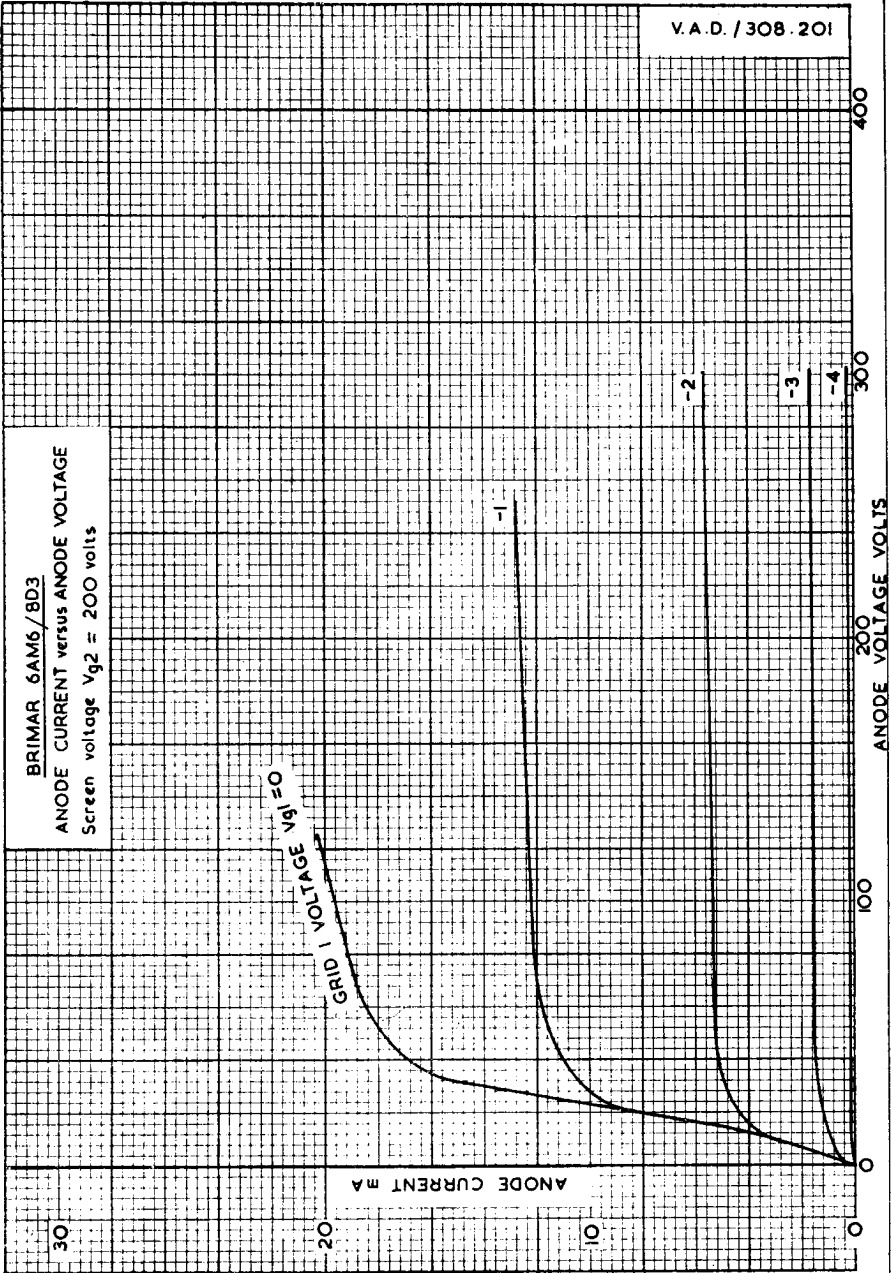


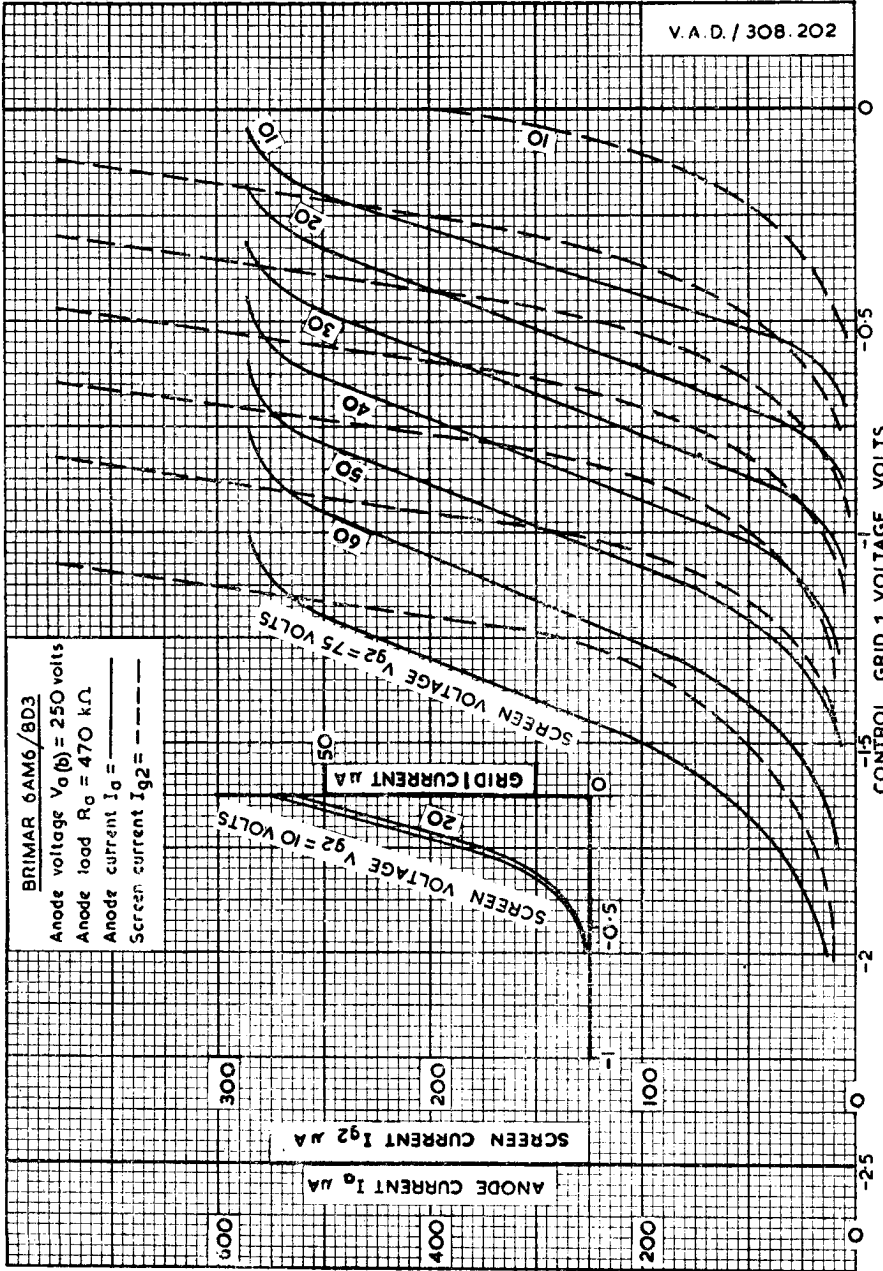
BRIMAR 6AM6 / 8D3
ANODE CURRENT versus ANODE VOLTAGE
Screen voltage $V_{g2} = 250$ volts

GRID 1 VOLTAGE $V_{g1} = 0$



BRIMAR 6AM6/BD3
ANODE CURRENT versus ANODE VOLTAGE
Screen voltage $V_{g2} = 200$ volts





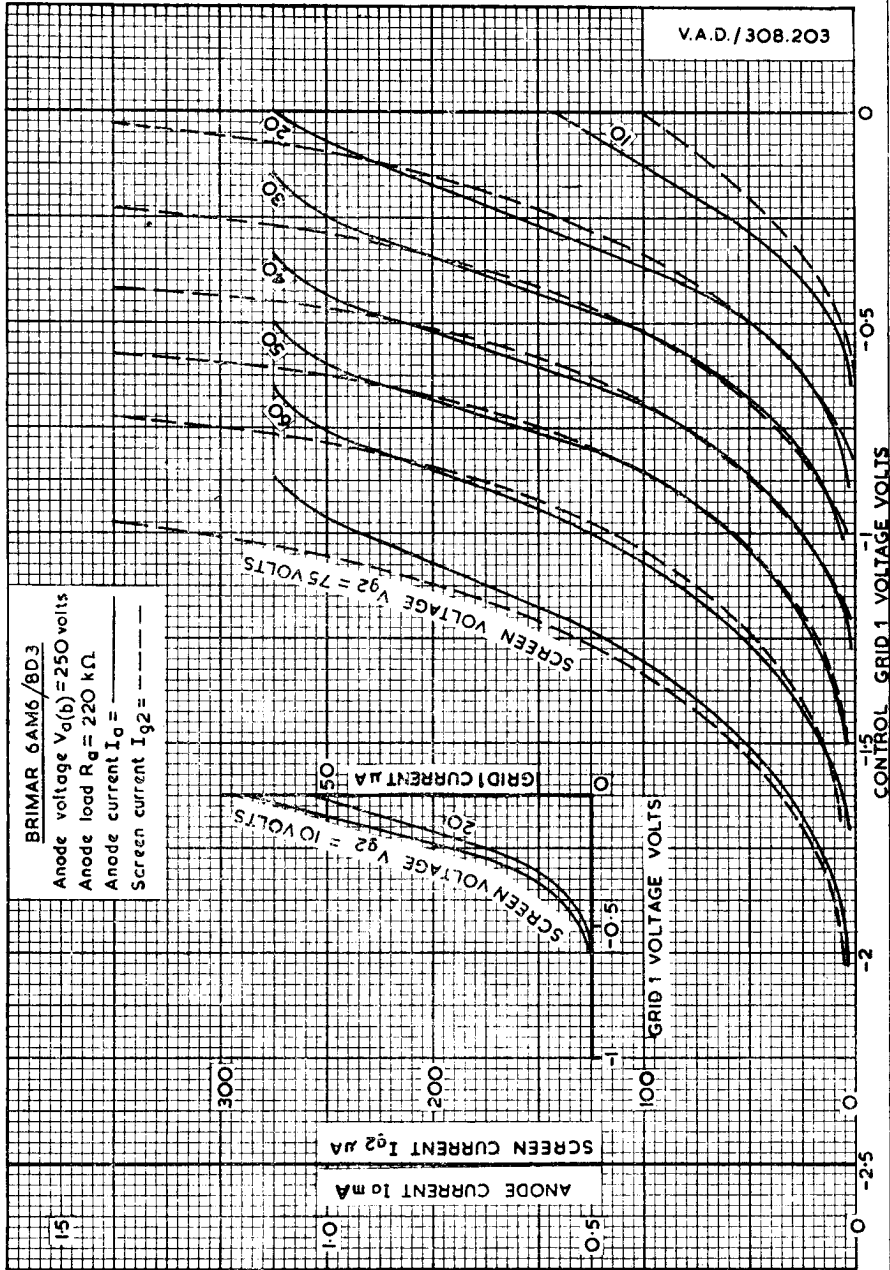
BRIMAR 6AM6/BD3

Anode voltage $V_a(b) = 250$ volts

Anode load $R_a = 220$ k Ω

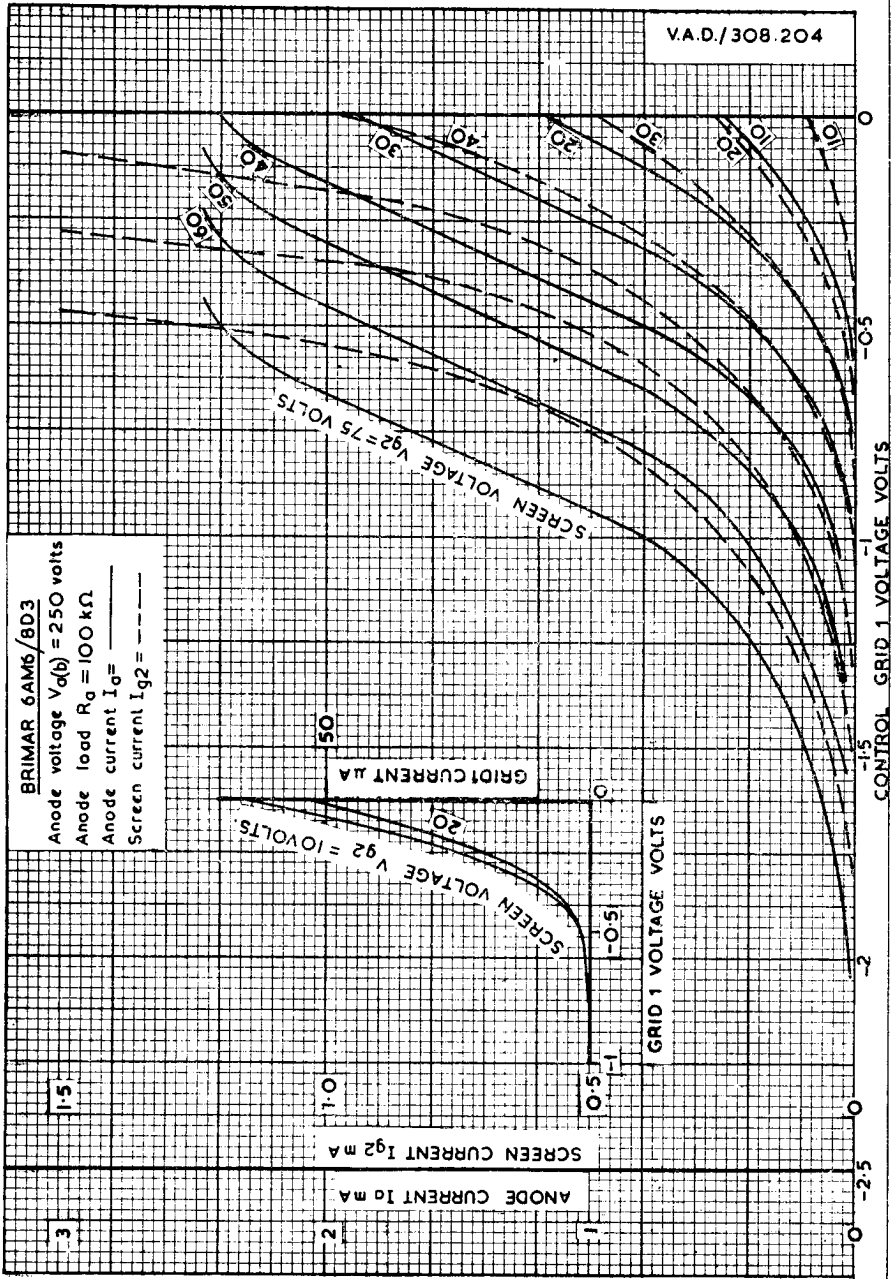
Anode current $I_a =$ -----

Screen current $I_{g2} =$ -----



BRIMAR 6AM6/8D3

Anode voltage $V_a(b) = 250$ volts
Anode load $R_a = 100$ k Ω
Anode current $I_a =$ _____
Screen current $I_{g2} =$ -----



V.A.D./3Q8.205

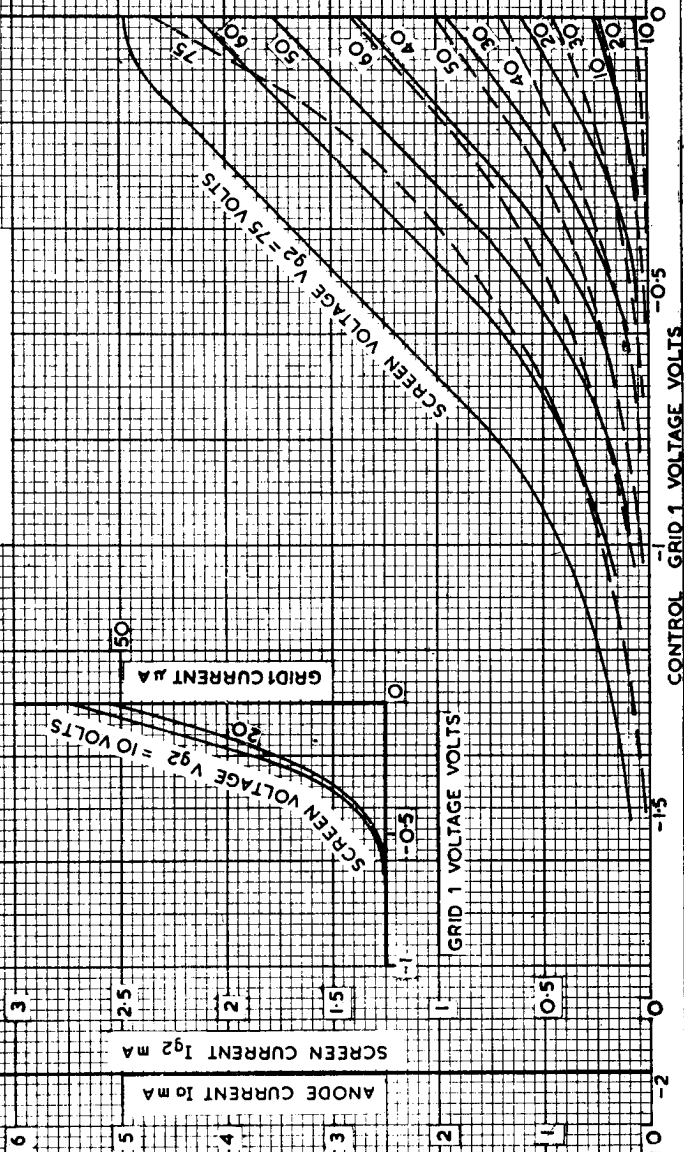
BRIMAR 6AM6/8D3

Anode voltage $V_{a(b)} = 250$ volts

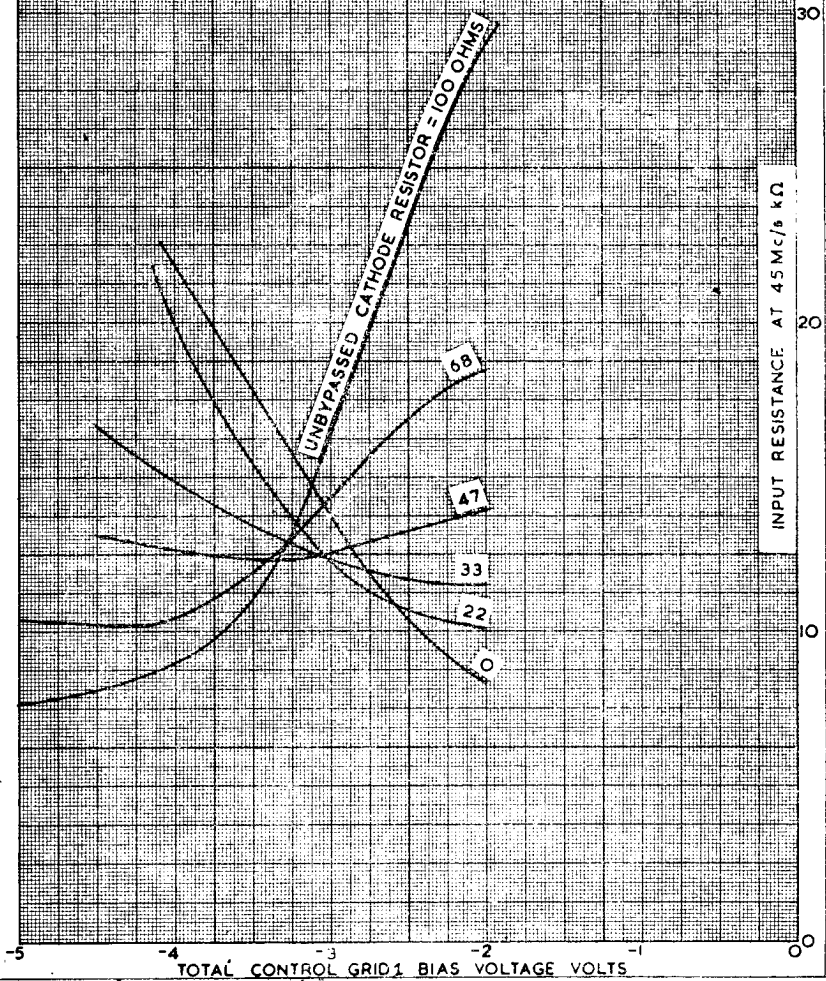
Anode load $R_a = 47$ k Ω .

Anode current $I_a =$ _____

Screen current $I_{g2} =$ -----



BRIMAR 6AM6/BD3
 Anode voltage $V_a = 250$ volts
 Screen voltage $V_{g2} = 250$ volts
 Cathode resistor $R_k = 160$ ohms
 Bypassed by $.01 \mu F$.



BRIMAR 6AM6 (8D3)

VOLTAGE GAIN versus FREQUENCY

Video amplifier

$R_d = 2.2k\Omega$

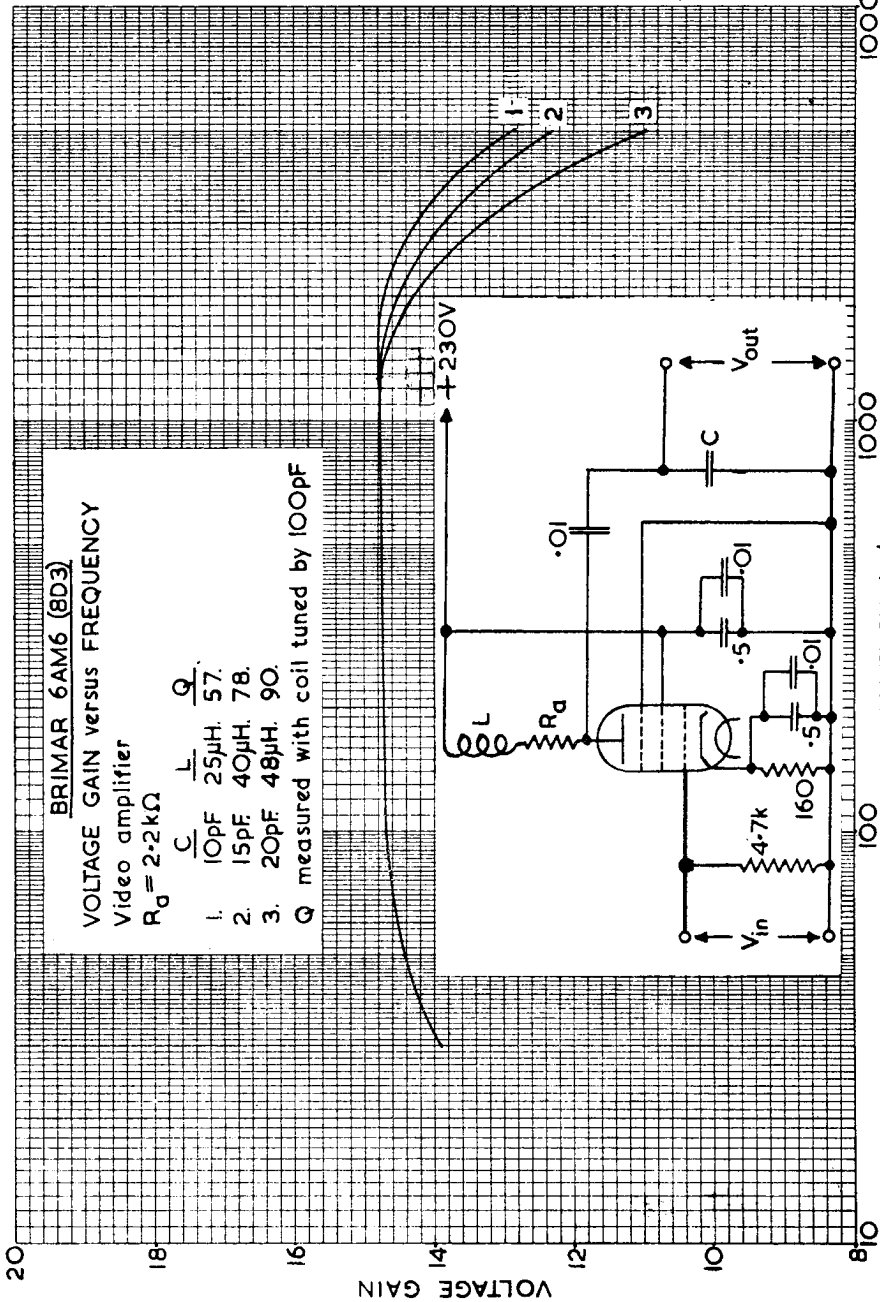
$\frac{C}{L} \quad \frac{Q}{L}$

1. 10pF 25μH. 57.

2. 15pF 40μH. 78.

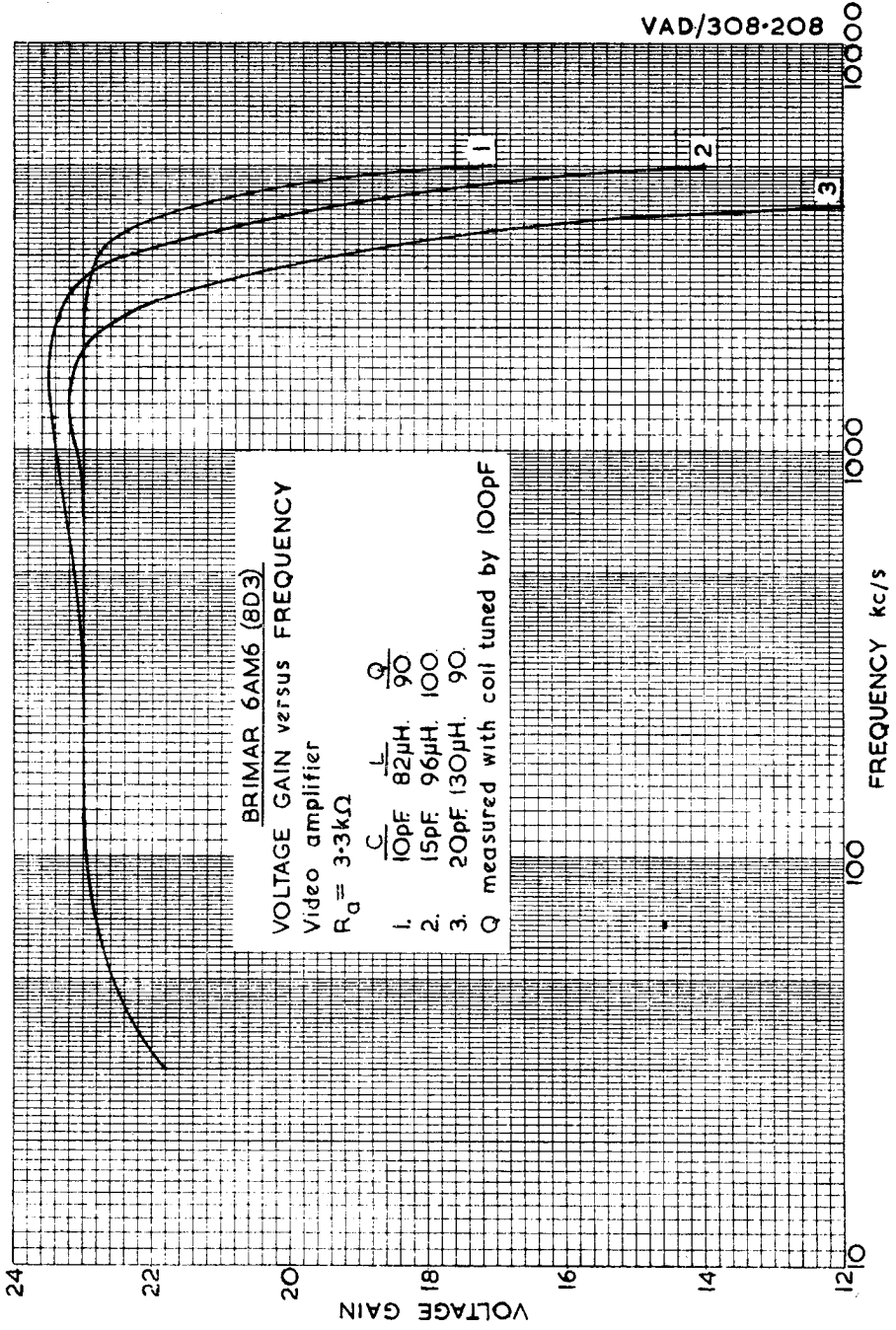
3. 20pF 48μH. 90.

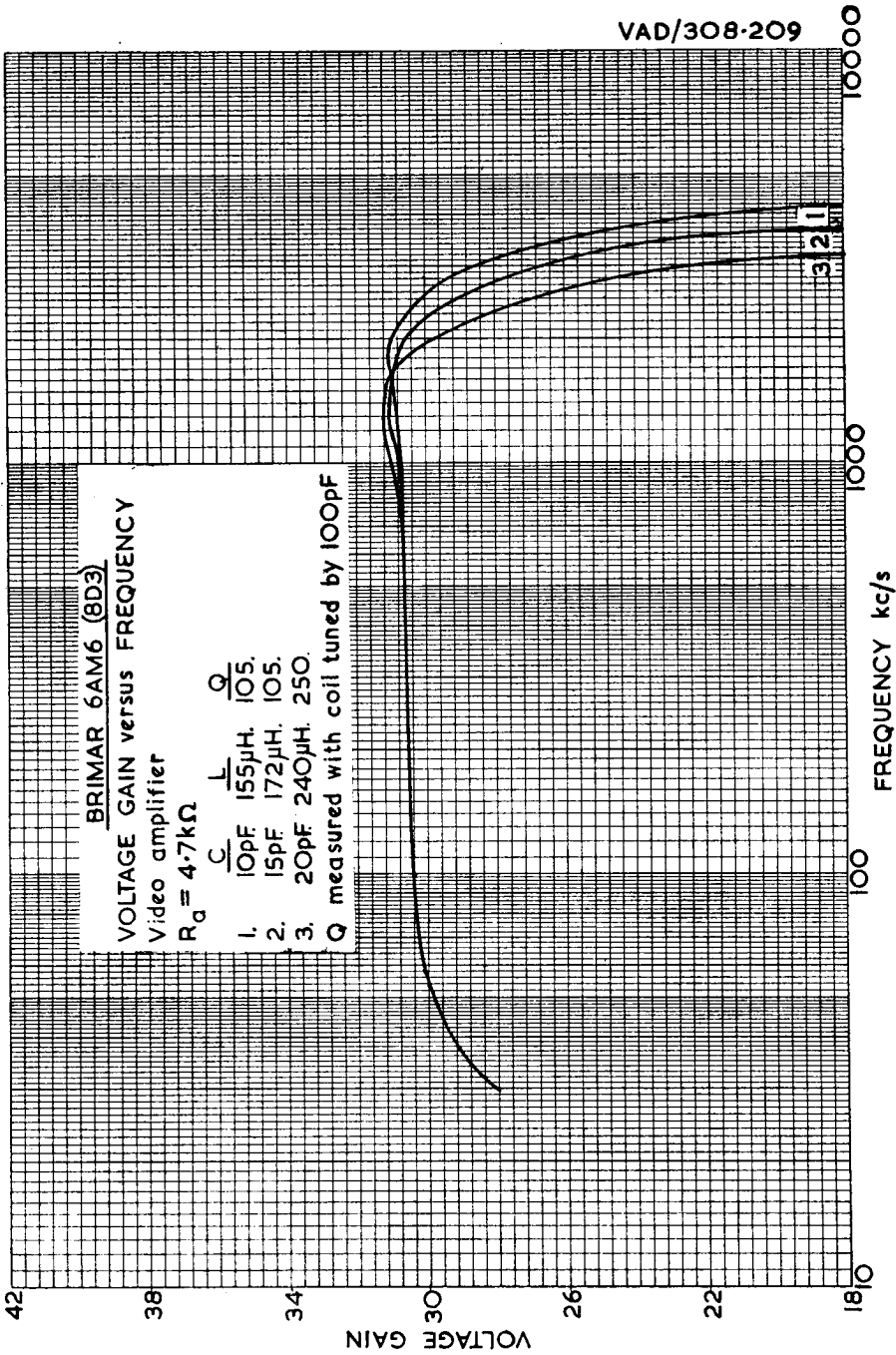
Q measured with coil tuned by 100pF

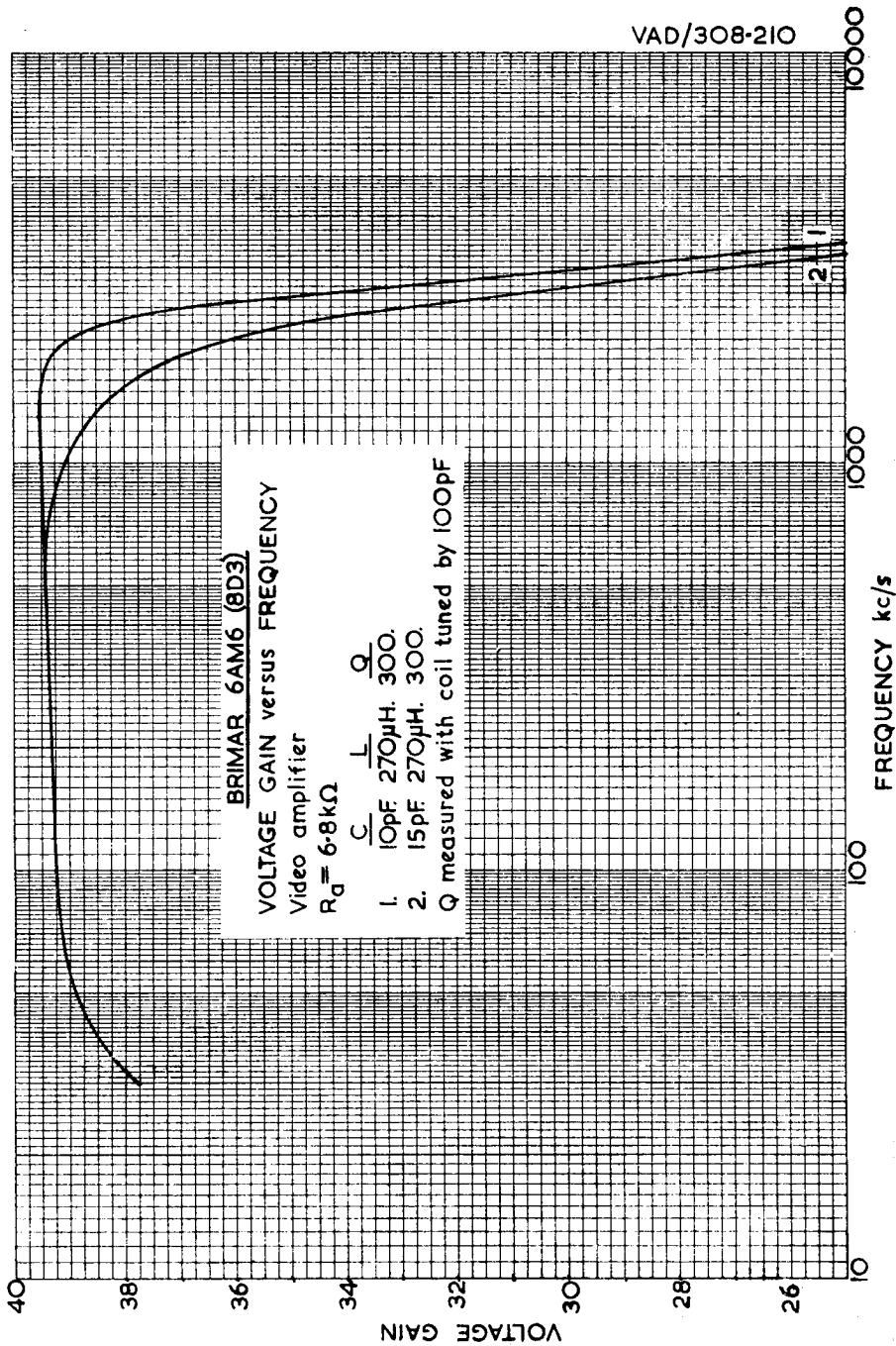


FREQUENCY kc/s

VOLTAGE GAIN







BRIMAR 6AM6 (8D3)

TRIODE CONNECTION

g_2 connected to anode

g_3 connected to cathode

Anode supply voltage $V_{a(b)} = 250$ Volts

Anode loads:- 1- $R_a = 47k\Omega$

2- $R_a = 100k\Omega$

3- $R_a = 220k\Omega$

ANODE IMPEDANCE r_a k Ω

1000
800
600
400
200
0

-6

-5

-4

-3

-2

-1

0

GRID VOLTAGE VOLTS

70
60
50
40

AMPLIFICATION FACTOR μ

0

8

6

ANODE CURRENT I_a mA

10
8
6
4
2
0

MUTUAL CONDUCTANCE g_m mA/V

2

0

1- μ

2- μ

3- μ

1- I_a

1- g_m

2- I_a

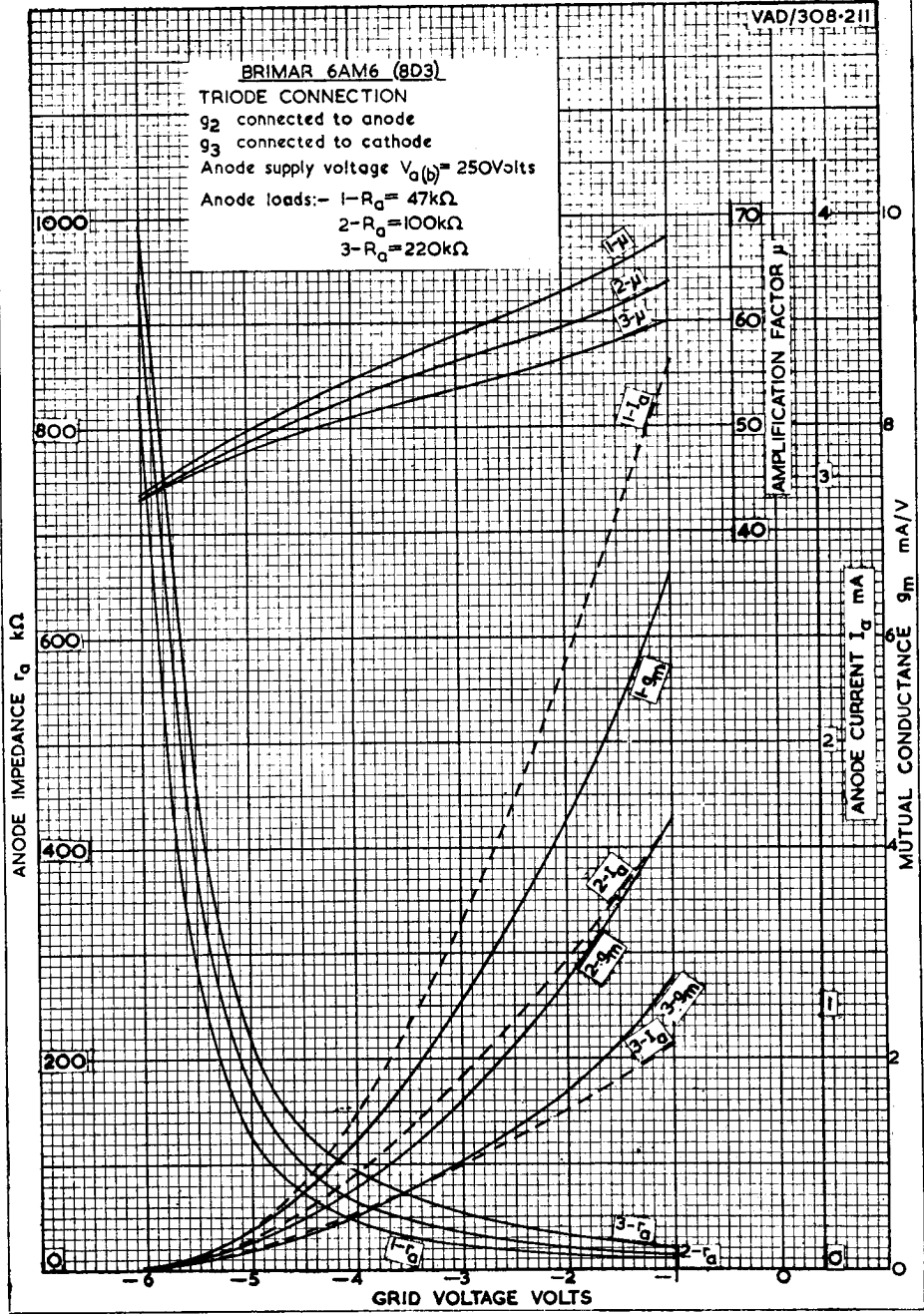
2- g_m

3- I_a

3- g_m

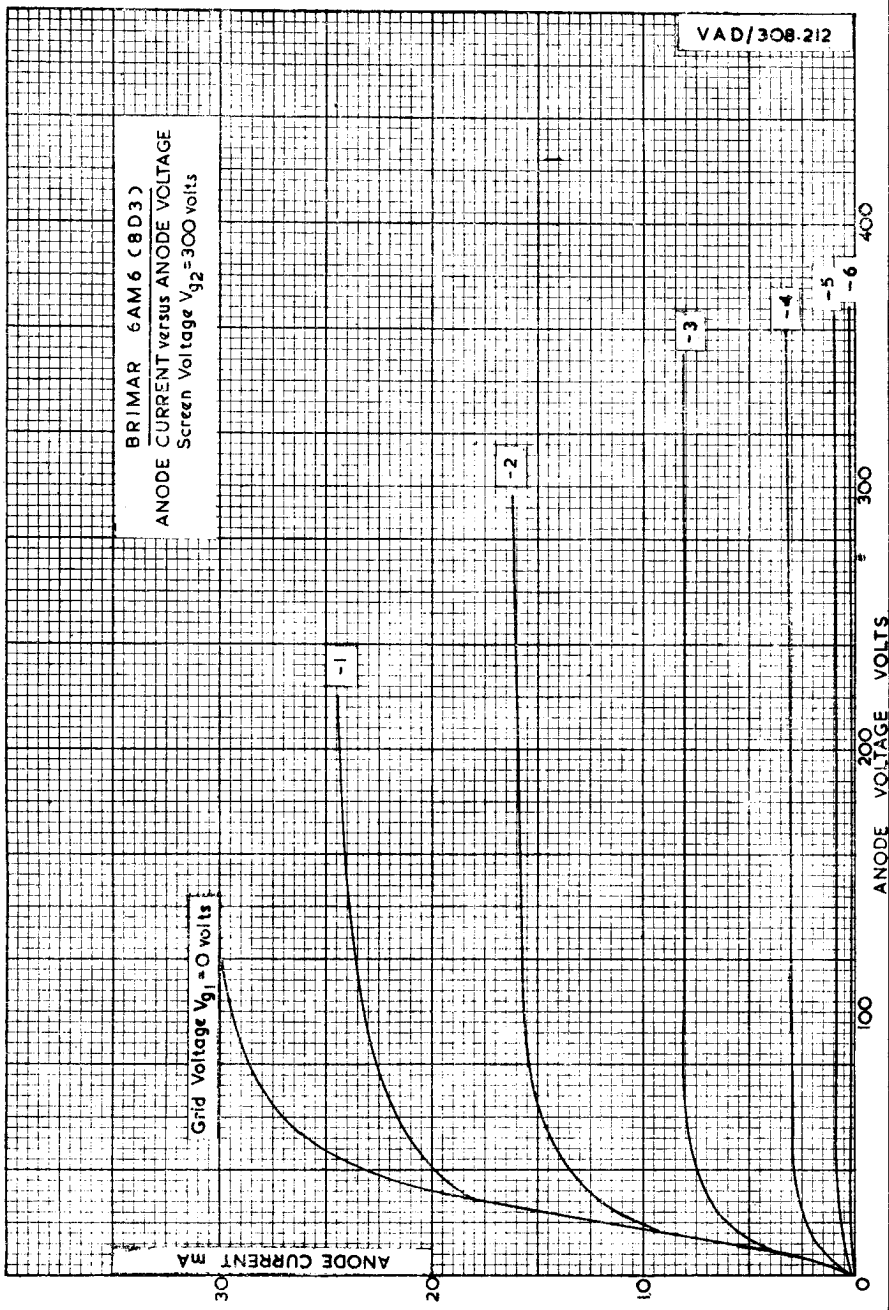
1- g_a

3- g_a

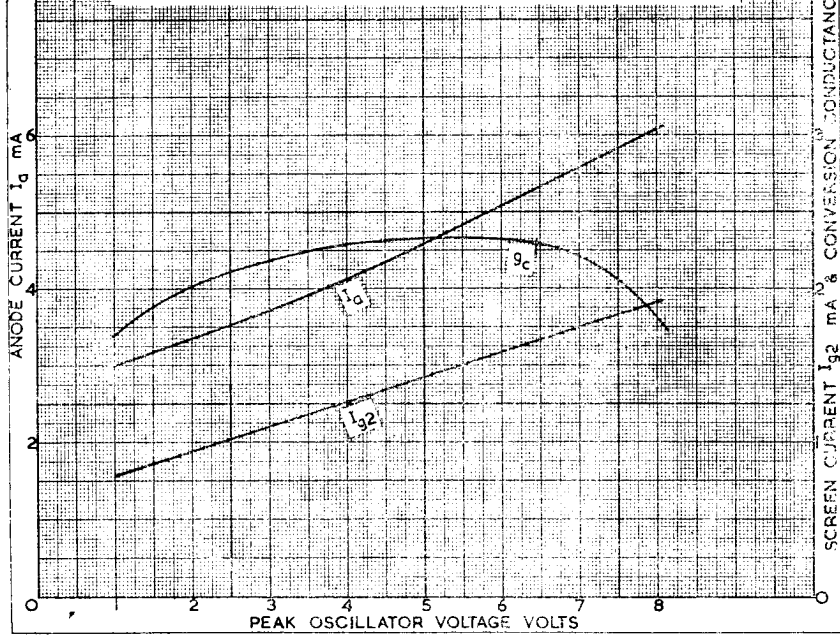
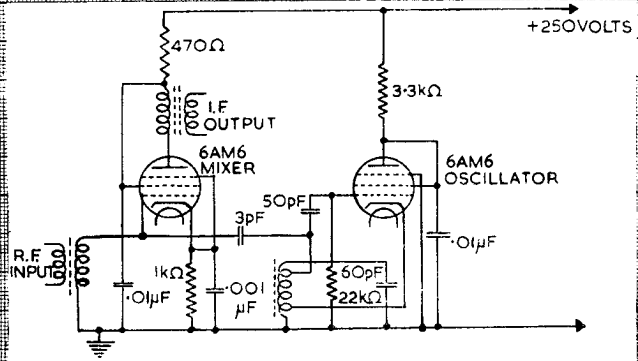


BRIMAR 6AM6 (BD3)
ANODE CURRENT versus ANODE VOLTAGE
Screen Voltage $V_{g2} = 300$ volts

Grid Voltage $V_{g1} = 0$ volts



BRIMAR 6AM6 (8D3)
 As a frequency changer. Grid injection of oscillator volts. Signal input = 0.1 Volts peak at television frequencies 40 to 70 Mc/s
 Anode & screen voltage = 250 Volts
 Cathode bias resistor $R_k = 1k\Omega$



BRIMAR 6AM6 (8D3)

Screen Current I_{g2} versus Grid 3 Voltage V_{g3}
 Grid 1 Voltage = 0 Volts

