BRIMAR

RECEIVING VALVE

6AU6

APPLICATION REPORT VAD/508.1

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

Issued January, 1949. Reprinted January, 1952.

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

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

CHARACTERISTICS:

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

Ratings:

PENTODE CONNECTIONS:

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

TRIODE CONNECTION (Pins 2, 5 and 6 strapped)

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

Capacities (approx.):*

PENTODE CONNECTED:

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

TRIODE CONNECTED:

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

* Measured with no external shield.

GROUNDED GRID OPERATION:

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

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

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

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

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

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

TYPICAL OPERATION

CLASS "A" AMPLIFIER:

Pentode connected (g_3 **connected to cathode**):

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

Triode Connected:

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

OPERATION AS AN RF OR IF AMPLIFIER:

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

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

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

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

Curves are attached to this report as follows:

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

OPERATION AS A RESISTANCE-CAPACITY COUPLED AMPLIFIER:

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

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

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

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

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

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

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

Triode Connected: The valve may be used as a triode R-C coupled amplifier, and a graph is attached to this report showing the relation between the various valve parameters under conditions of resistance coupling. This graph (No. 308·37) is taken at an anode supply voltage ($V_{a(b)}$) of 250 volts with three values of anode load resistor, viz., 47,000, 100,000 and 220,000 ohms and plots the anode current, amplification factor, mutual conductance and anode impedance against grid voltage. From this graph the correct grid bias (cathode resistor) can be obtained, also the stage gain can be calculated and an estimate made of the distortion. The graph is not drawn beyond the limits of start of grid current or around the grid cut-off region.

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

If for example it is desired to use a valve at a supply voltage of 250 volts, and anode load of 220,000 ohms and a succeeding valve grid leak of 470,000 ohms, then to determine the grid bias an inspection of the graph indicates a relatively linear portion of the curve of anode current/grid volts over the range of —1 to —6 volts, the mid point being —3·5 volts. At this point the anode current is 0·67 mA hence the cathode resistance should be 520 ohms. The peak input voltage is 2·5 volts and the R.M.S. input 1·75 volts. Following the grid bias voltage upward on the curve it is evident that with an anode load of 220,000 ohms, the amplification factor (μ) is 29, and the anode impedance is 26,000 ohms. The anode load is effectively in parallel with the succeeding valve grid leak as regards the signal but not as regards the anode current, hence the effective signal value of the anode load is 220,000 ohms in parallel with 470,000 ohms or is 150,000 ohms. The stage gain is:

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

or in the above case:

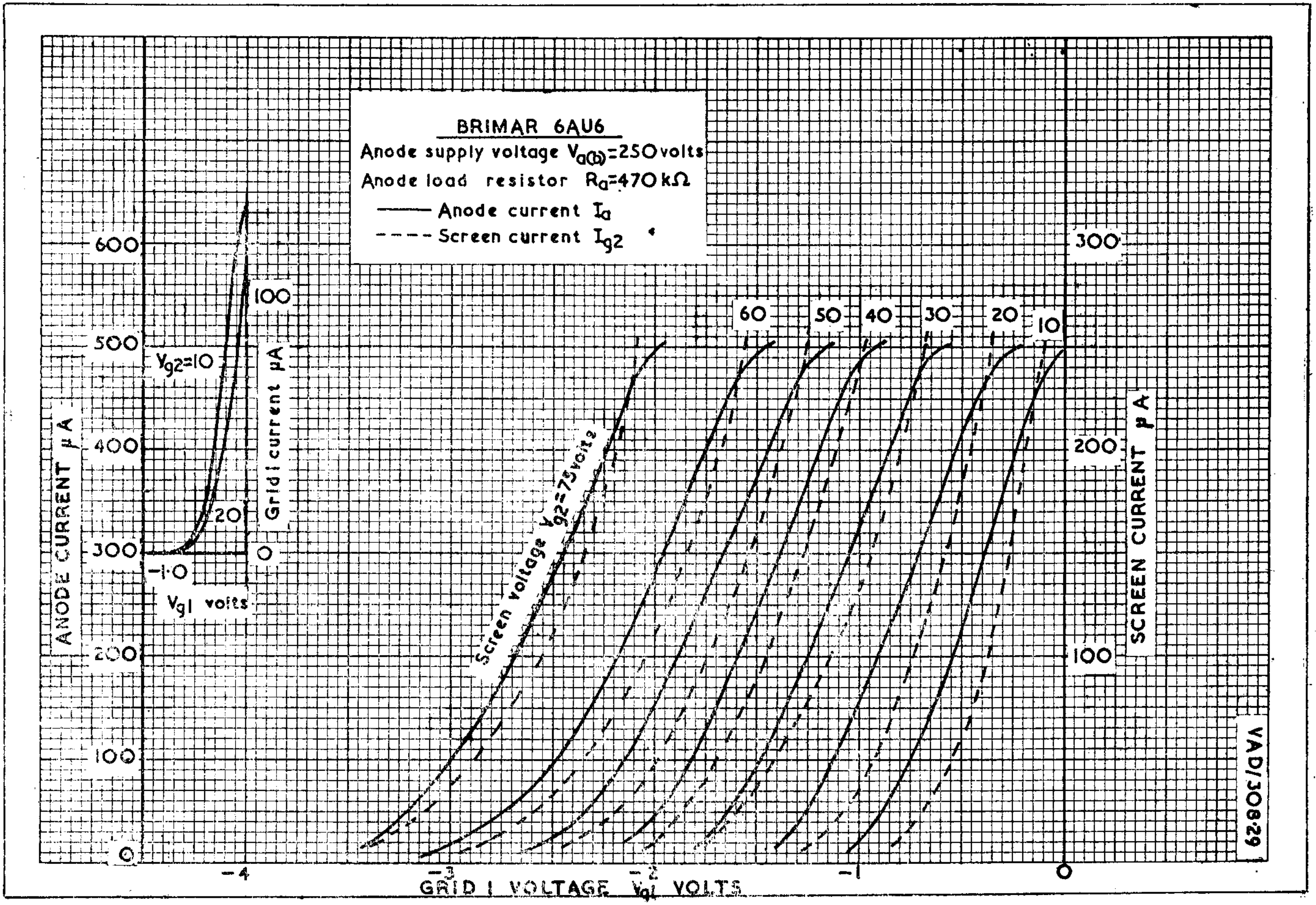
$$\frac{29 \times 150{,}000}{150{,}000 + 26{,}000} = 25$$

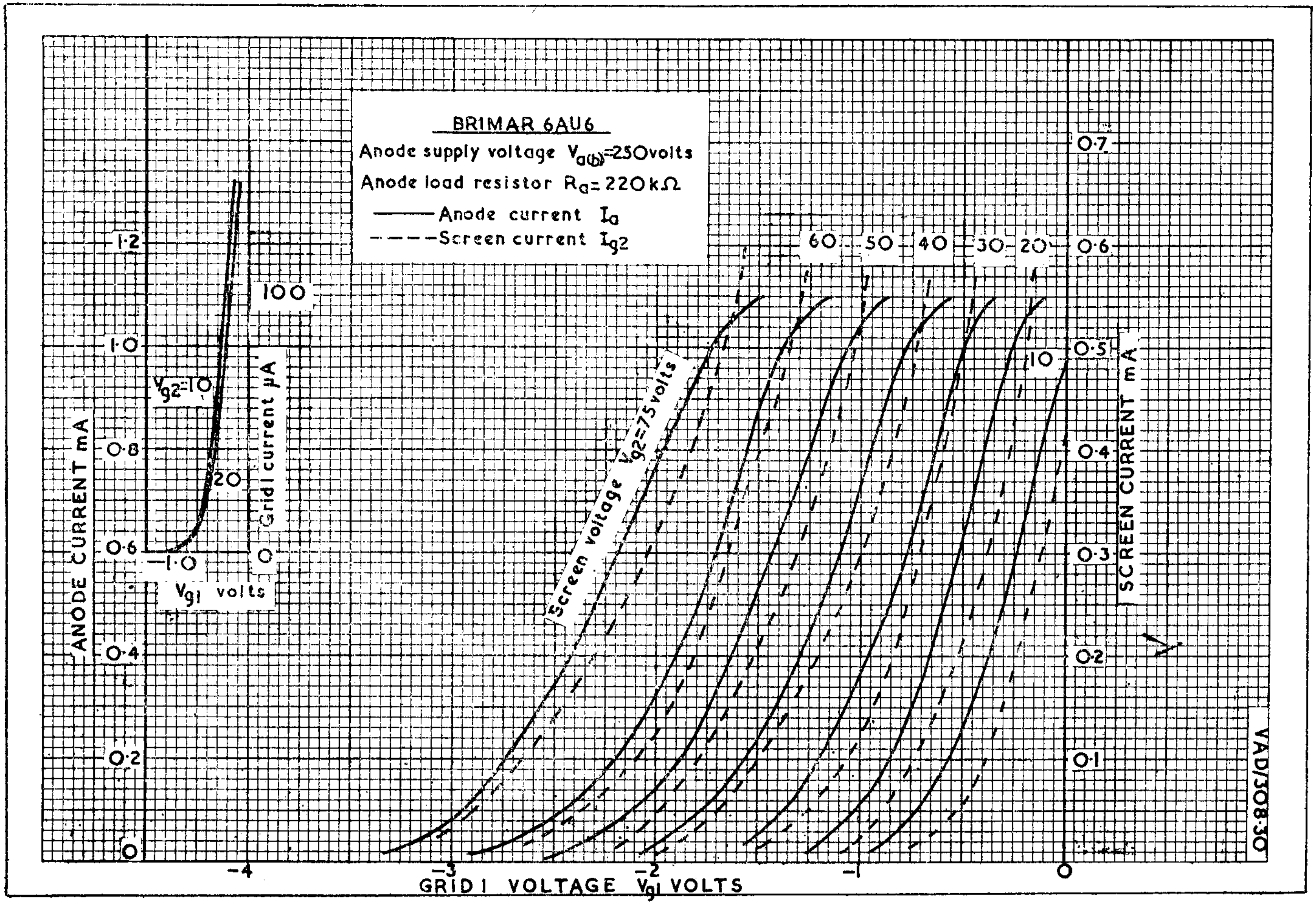
The peak input voltage above was 2·5 volts hence the peak output voltage will be this figure multiplied by the stage gain or 62 volts or 44 volts R.M.S.

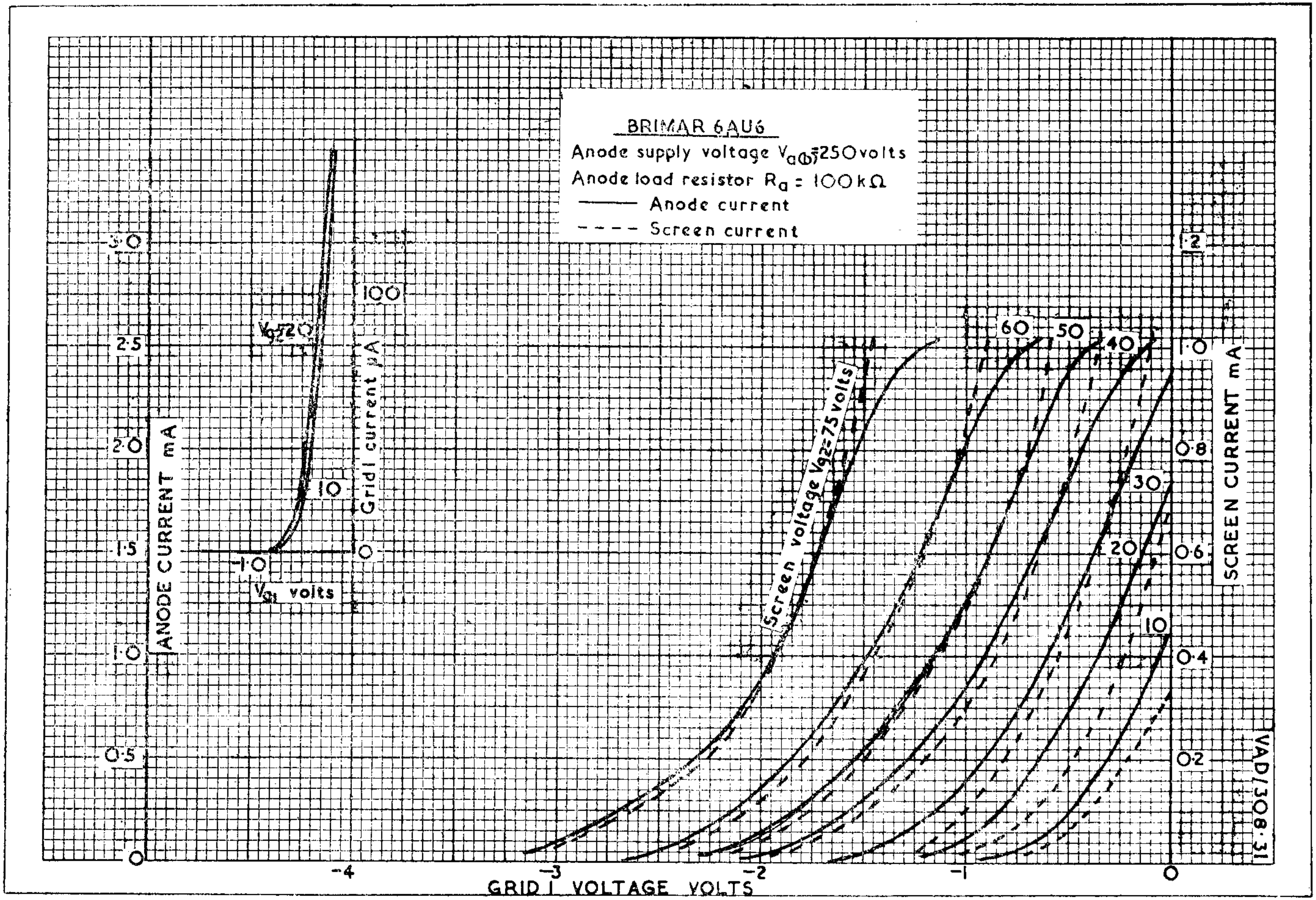
An estimate of the distortion may be made by calculating from the graph as above the stage gain at the extremes of grid bias; in the example the stage gain at —1 volts is 30 and at —6 volts is 20, hence the positive peaks of the signal output will be less than the negative.

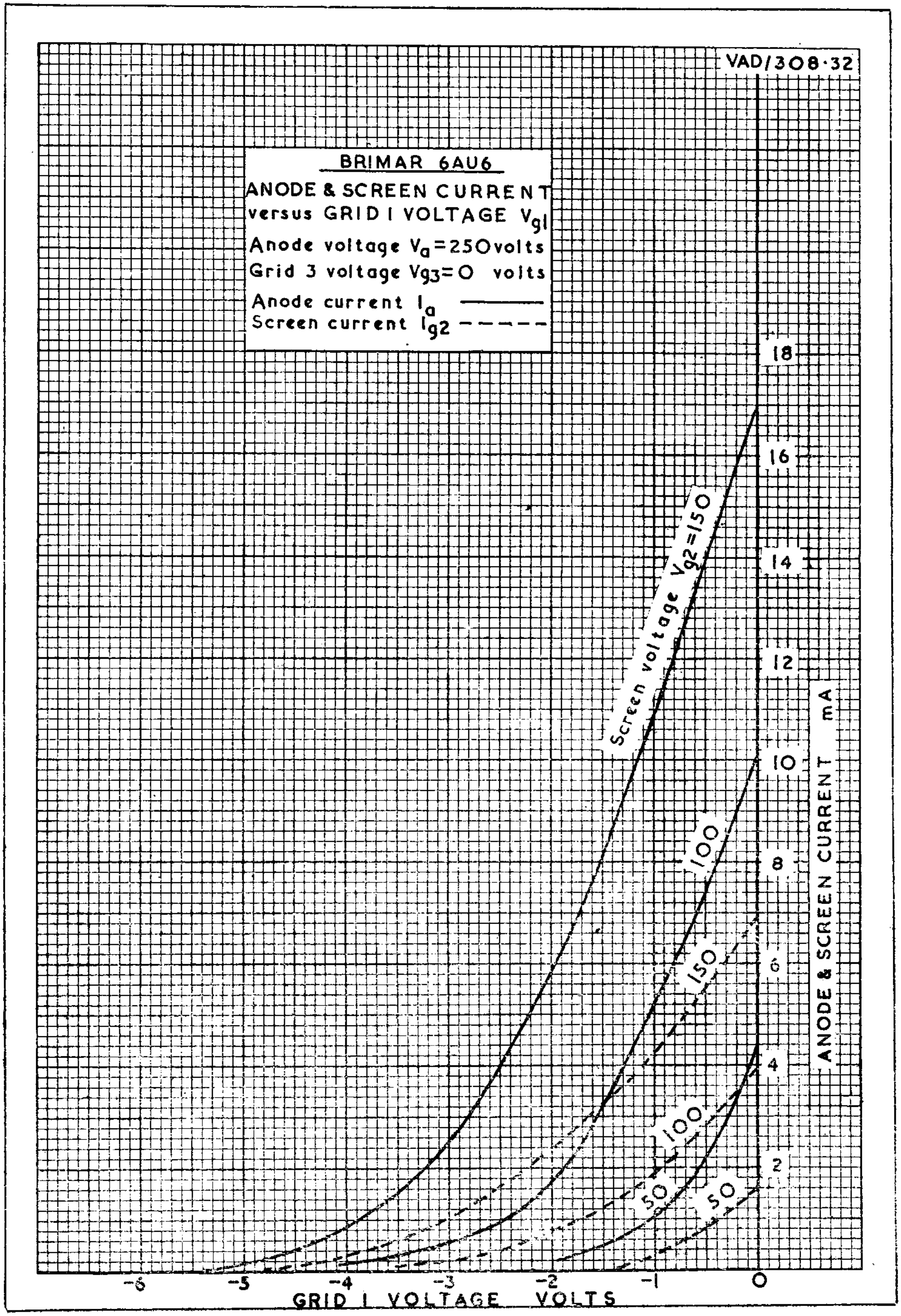
OPERATION AS AN FM LIMITER:

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

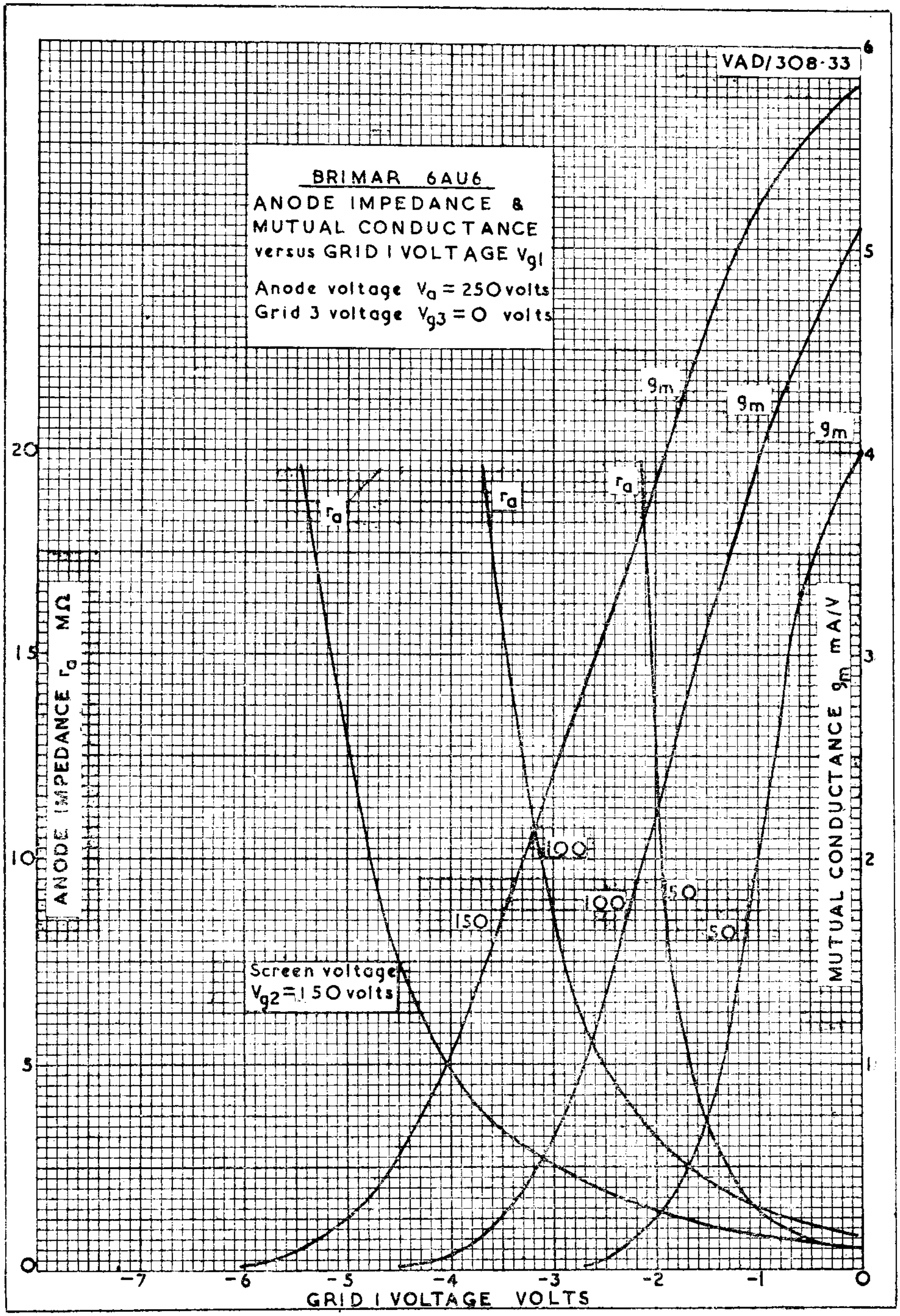

BRIMAR 6AU6
Anode supply voltage Va(b)=250 volts
Anode load resistor Ra=470 kΩ
Anode current Ia
Screen current Ig2
ANODE CURRENT µA
SCREEN CURRENT µA
GRID I VOLTAGE Vg1 VOLTS
Grid I current µA
Vg1 volts
Vg2=10
Screen voltage Vg2=75 volts
10
20
30
40
50
60
VAD/308·29

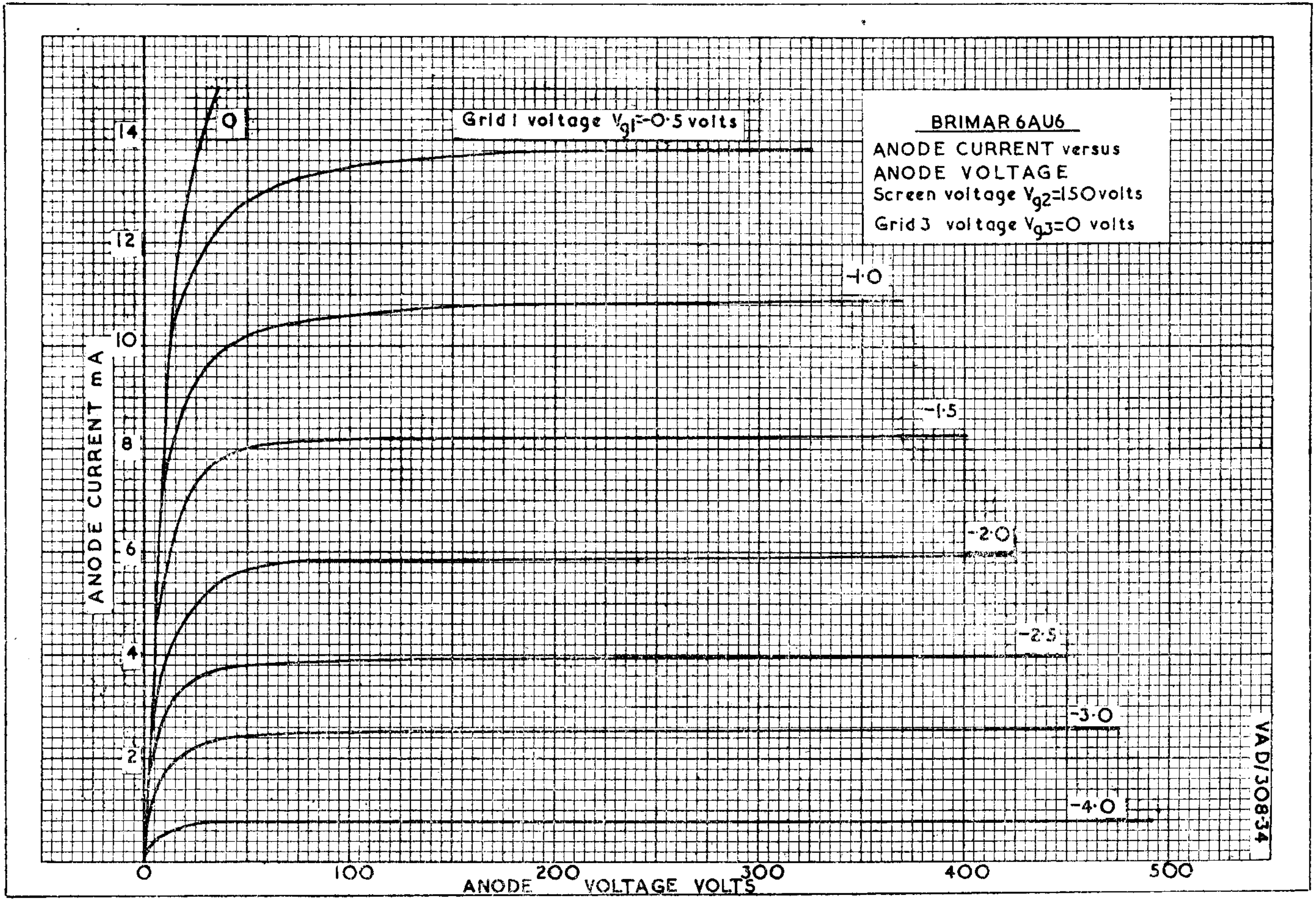

BRIMAR 6AU6
Anode supply voltage $V_{a(b)}$=250volts
Anode load resistor R_a= 220kΩ
——Anode current I_a
- - - -Screen current I_{g2}
60 50 40 30 20 10
Screen voltage V_{g2}=75volts
V_{g2}=10
Grid1 current μA
100
20
0
-1·0
V_{g1} volts
ANODE CURRENT mA
1·2
1·0
0·8
0·6
0·4
0·2
0
SCREEN CURRENT mA
0·7
0·6
0·5
0·4
0·3
0·2
0·1
-4
-3
-2
-1
0
GRID1 VOLTAGE V_{g1} VOLTS
VAD/308·30

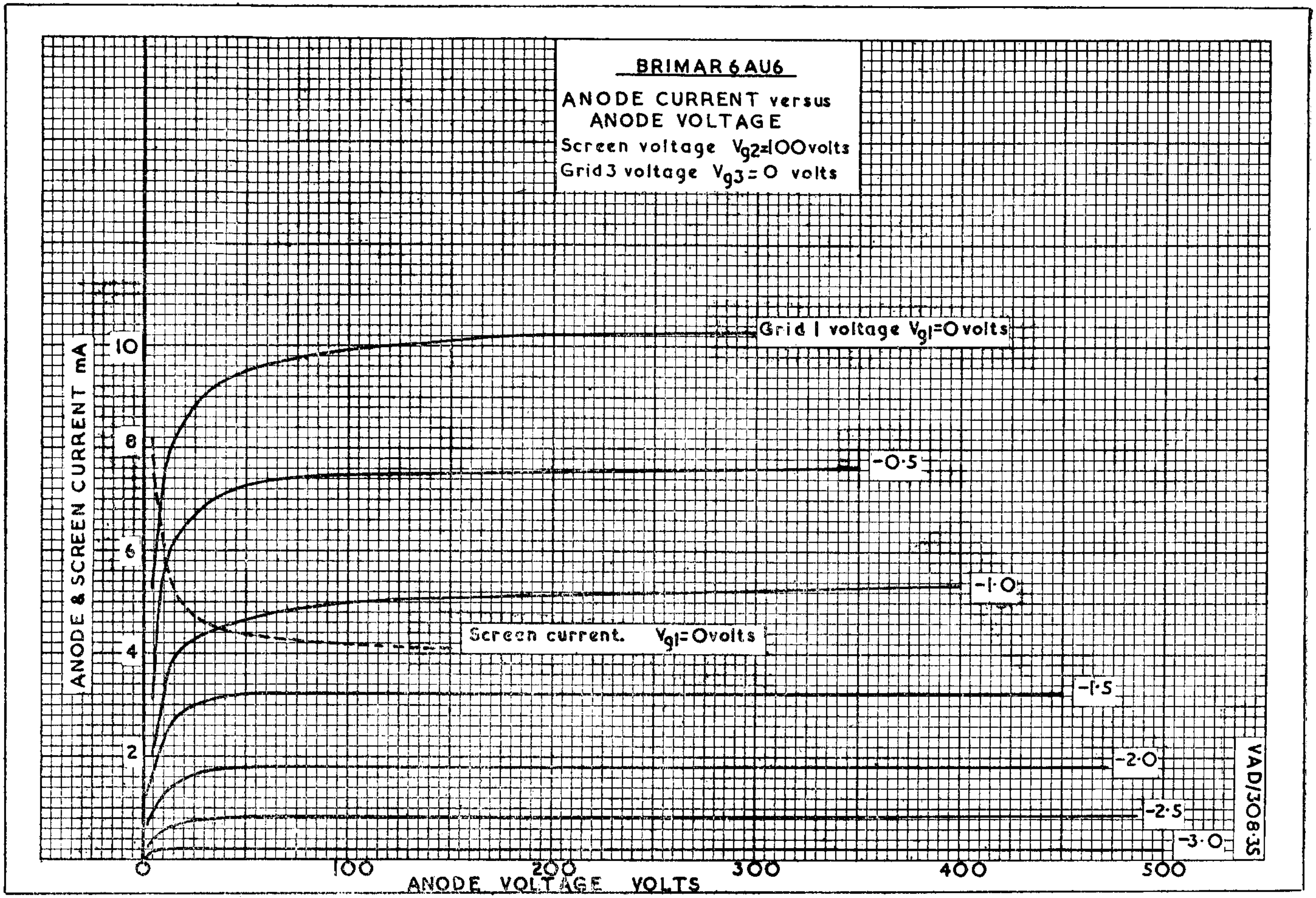

BRIMAR 6AU6
Anode supply voltage Va(b)=250volts
Anode load resistor Ra = 100kΩ
Anode current
Screen current
ANODE CURRENT mA
SCREEN CURRENT mA
GRID 1 VOLTAGE VOLTS
Grid1 current μA
Vg1 volts
Vg2=20
Screen voltage Vg2=75 volts
60
50
40
30
20
10
VAD/308·31



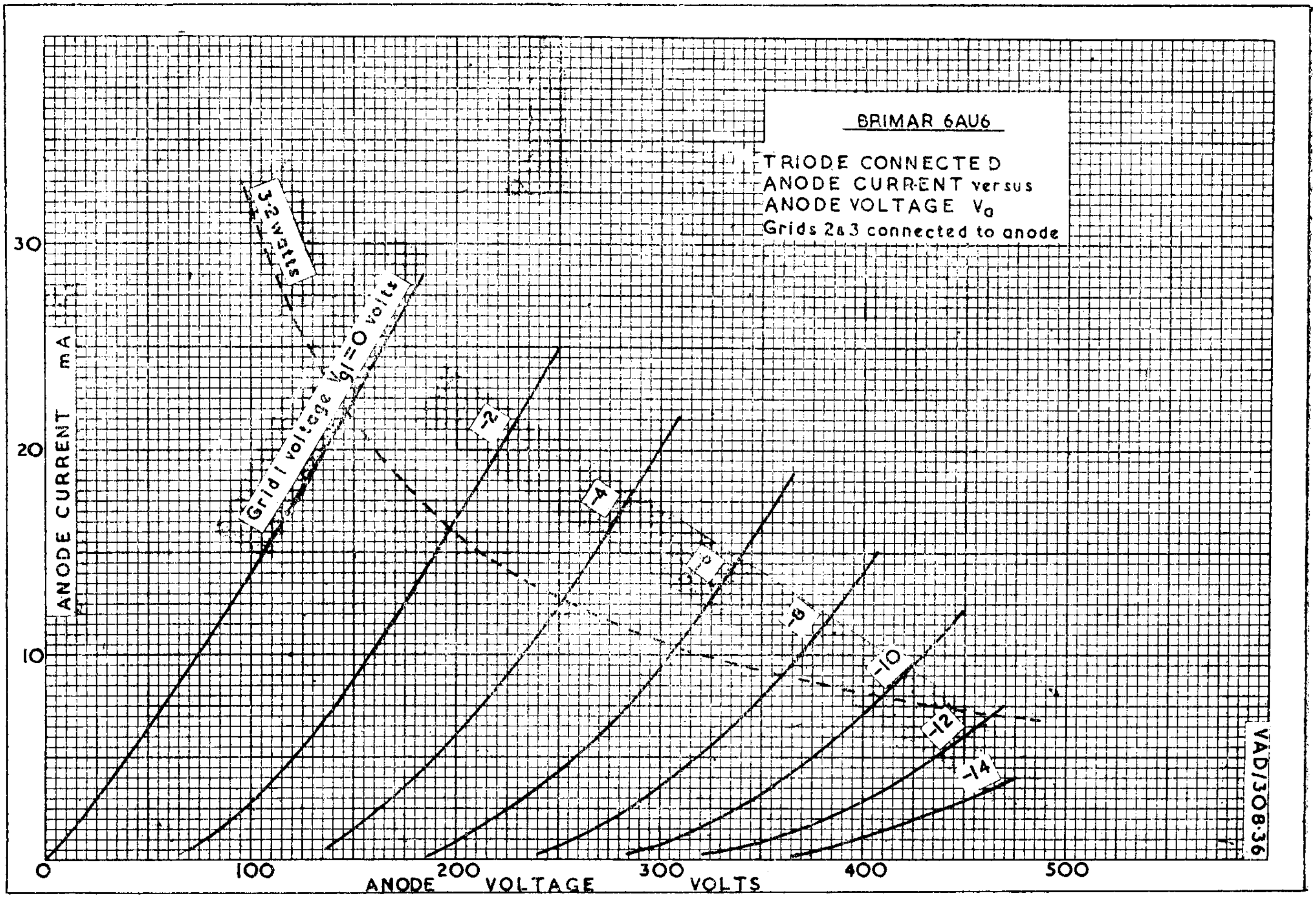
VAD/308·32
BRIMAR 6AU6
ANODE & SCREEN CURRENT
versus GRID I VOLTAGE Vg1
Anode voltage Va=250 volts
Grid 3 voltage Vg3=0 volts
Anode current Ia
Screen current Ig2
Screen voltage Vg2=150
100
150
100
50
50
18
16
14
12
10
8
6
4
2
ANODE & SCREEN CURRENT mA
-6
-5
-4
-3
-2
-1
0
GRID I VOLTAGE VOLTS

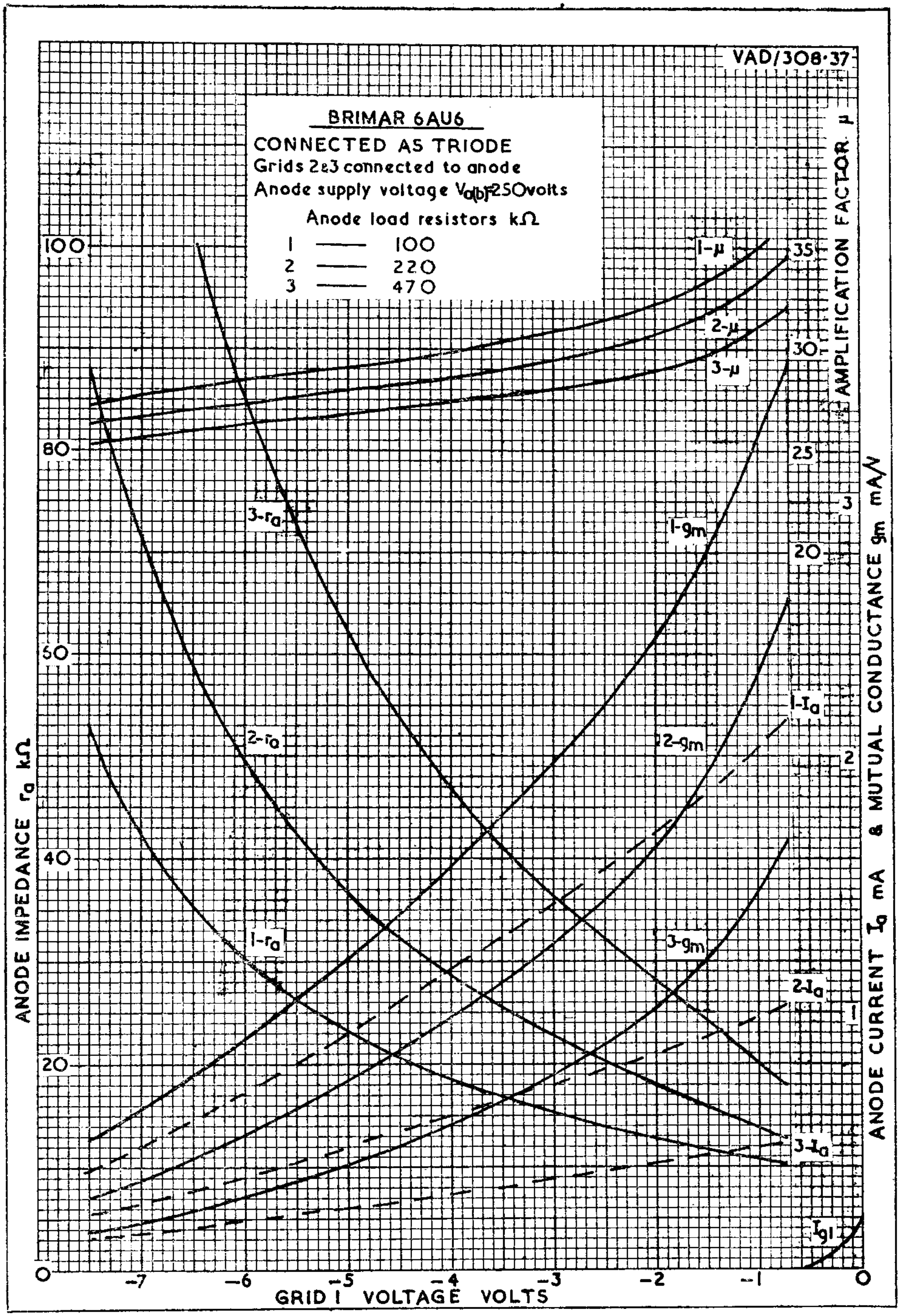

VAD/308·33
BRIMAR 6AU6
ANODE IMPEDANCE & MUTUAL CONDUCTANCE versus GRID I VOLTAGE V_{g1}
Anode voltage $V_a = 250$ volts
Grid 3 voltage $V_{g3} = 0$ volts
Screen voltage $V_{g2} = 150$ volts
g_m
r_a
150
100
50
ANODE IMPEDANCE r_a MΩ
MUTUAL CONDUCTANCE g_m mA/V
GRID I VOLTAGE VOLTS
−7
−6
−5
−4
−3
−2
−1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

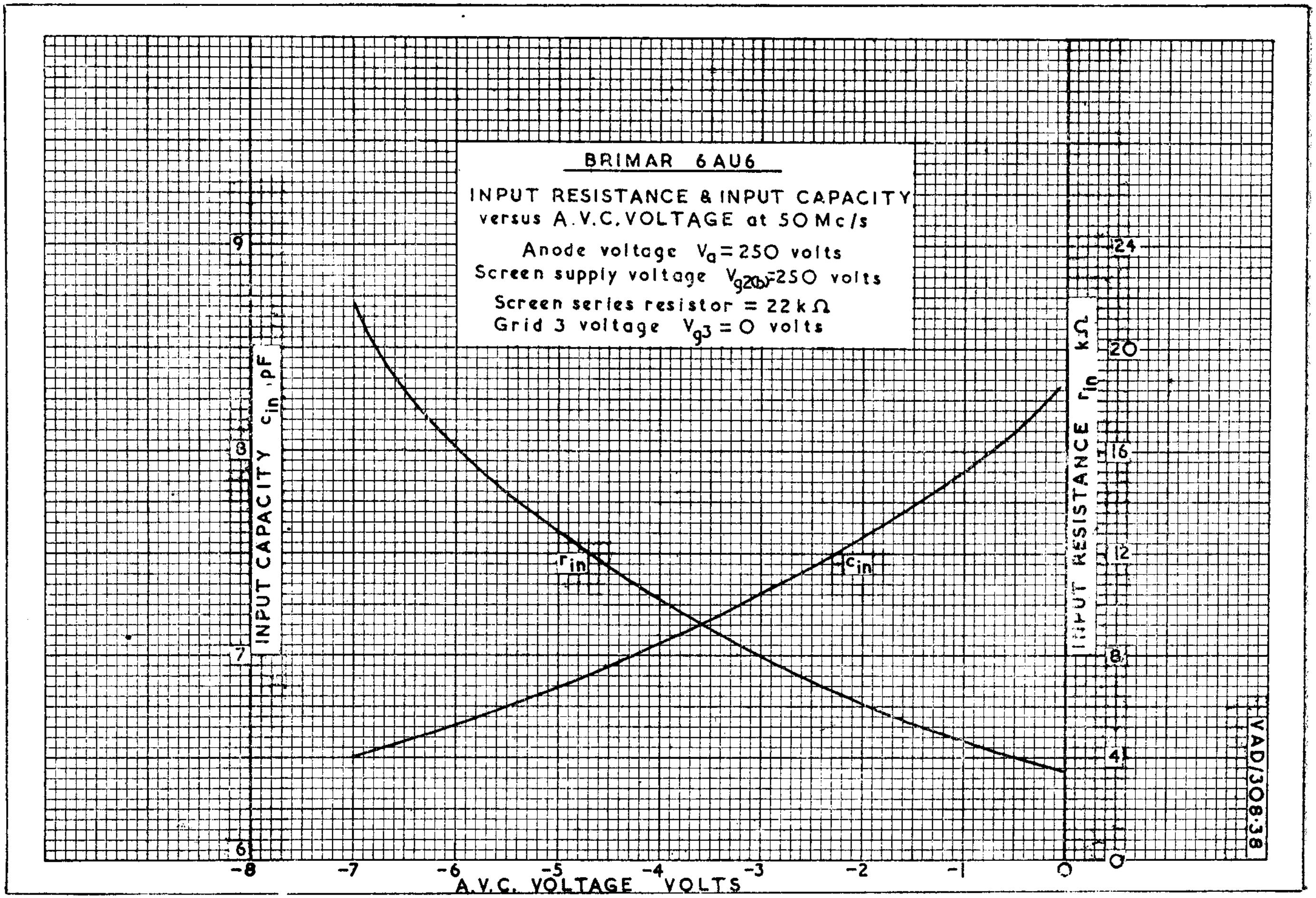

BRIMAR 6AU6
ANODE CURRENT versus
ANODE VOLTAGE
Screen voltage Vg2=150 volts
Grid 3 voltage Vg3=0 volts
Grid 1 voltage Vg1=-0·5 volts
0
-1·0
-1·5
-2·0
-2·5
-3·0
-4·0
ANODE CURRENT mA
14
12
10
8
6
4
2
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VA D/308·34

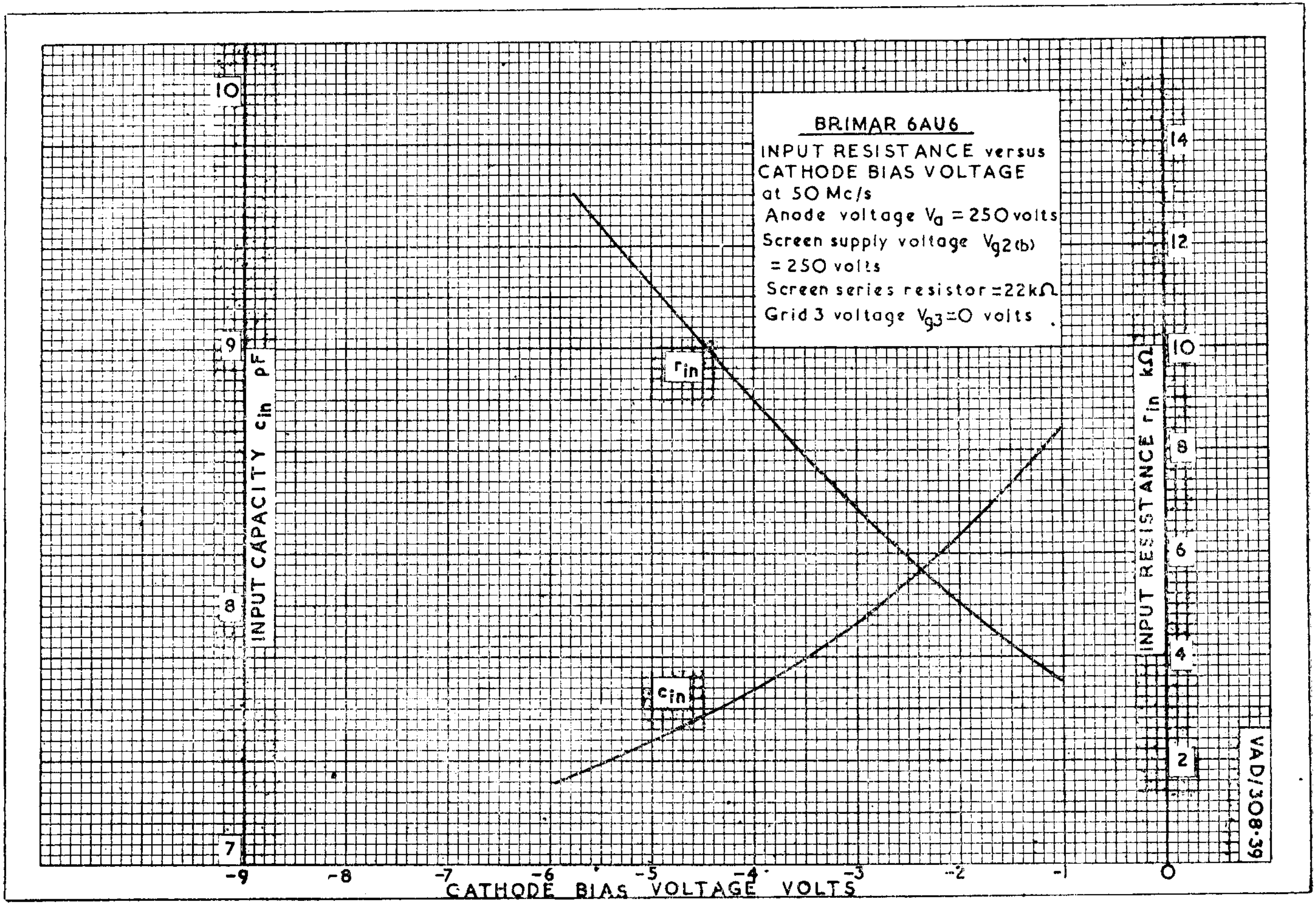


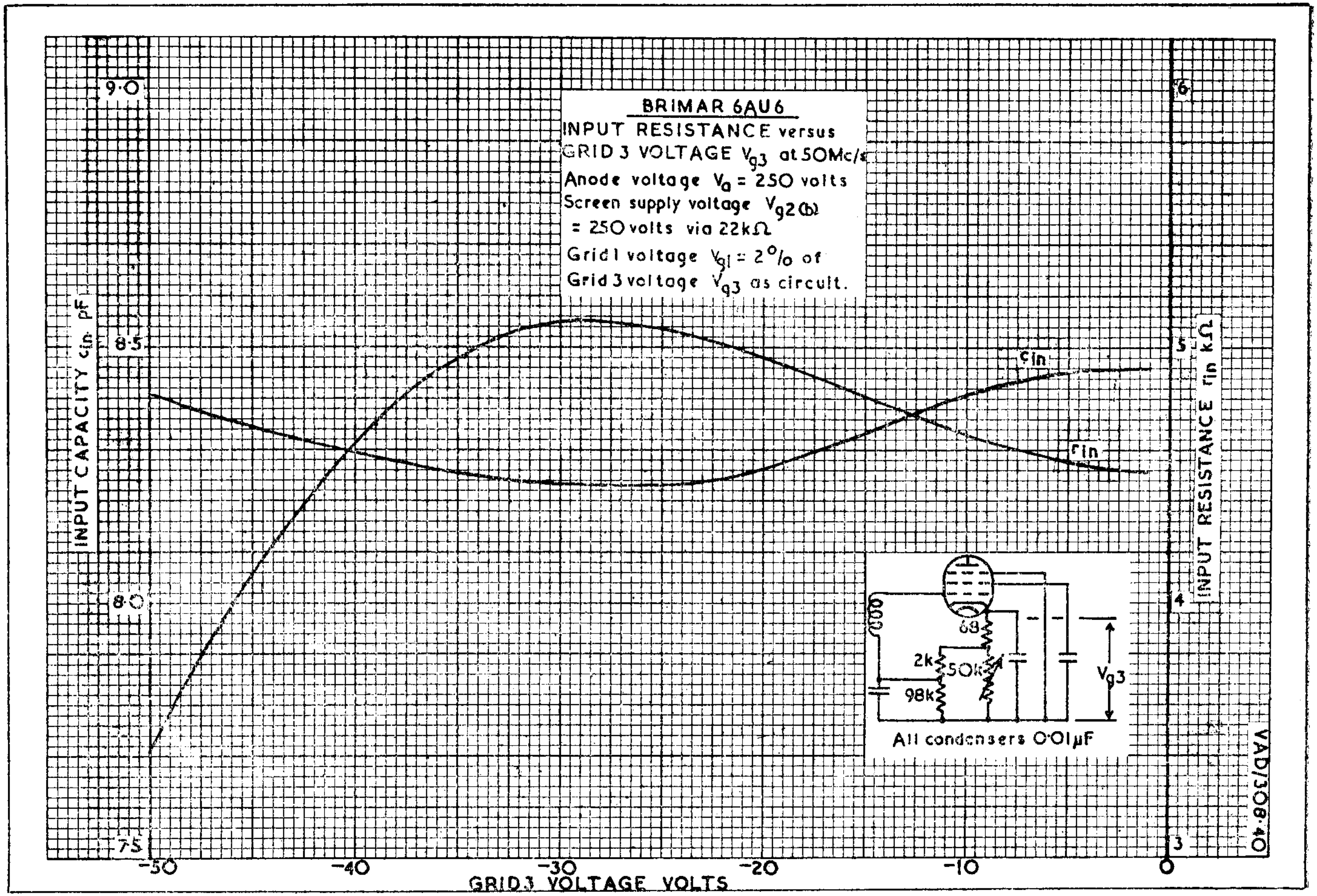
BRIMAR 6AU6
ANODE CURRENT versus ANODE VOLTAGE
Screen voltage V_{g2}=100 volts
Grid 3 voltage V_{g3} = 0 volts
Grid 1 voltage V_{g1}=0 volts
-0·5
-1·0
-1·5
-2·0
-2·5
-3·0
Screen current. V_{g1}= 0 volts
ANODE & SCREEN CURRENT mA
10
8
6
4
2
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VAD/308·35

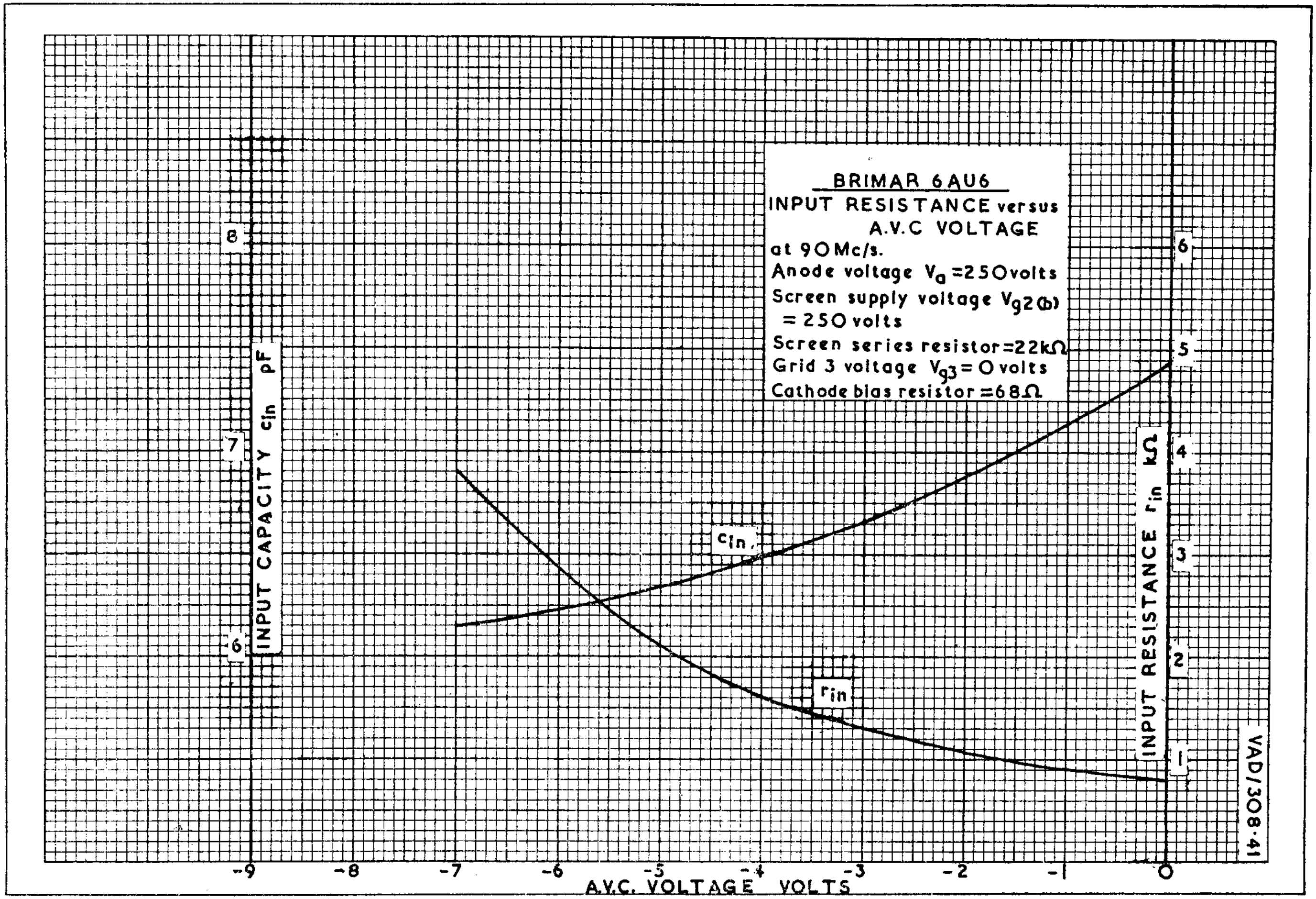

BRIMAR 6AU6
TRIODE CONNECTED
ANODE CURRENT versus
ANODE VOLTAGE Va
Grids 2 & 3 connected to anode
3·2 watts
Grid I voltage Vg1 = 0 volts
-2
-4
-6
-8
-10
-12
-14
ANODE CURRENT mA
10
20
30
0
100
200
300
400
500
ANODE VOLTAGE VOLTS
VAD/308·36

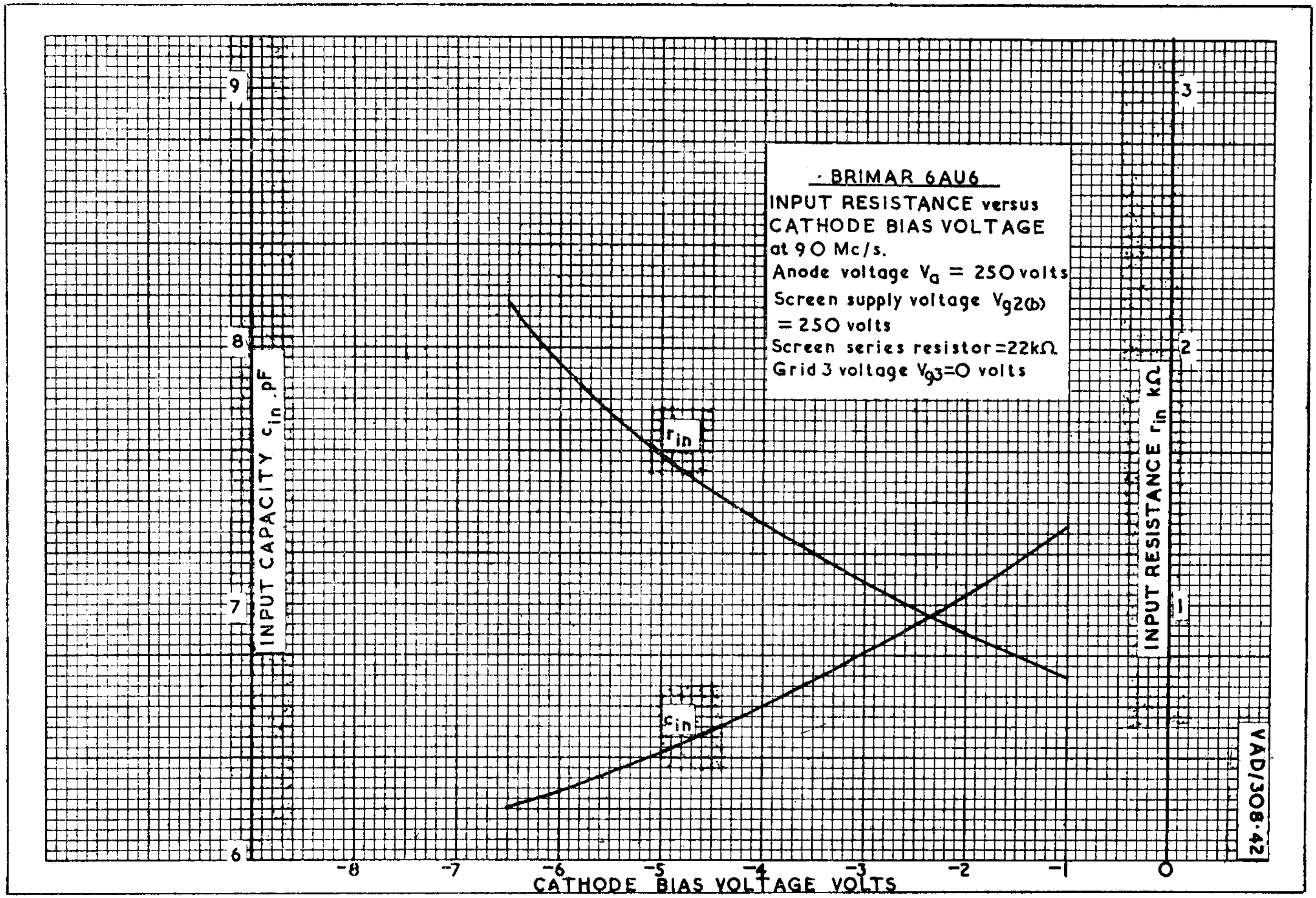

VAD/308·37
BRIMAR 6AU6
CONNECTED AS TRIODE
Grids 2&3 connected to anode
Anode supply voltage Va(b)=250volts
Anode load resistors kΩ
1 —— 100
2 —— 220
3 —— 470
1-μ
2-μ
3-μ
3-ra
2-ra
1-ra
1-gm
2-gm
3-gm
1-Ia
2-Ia
3-Ia
Ig1
ANODE IMPEDANCE ra kΩ
AMPLIFICATION FACTOR μ
ANODE CURRENT Ia mA & MUTUAL CONDUCTANCE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

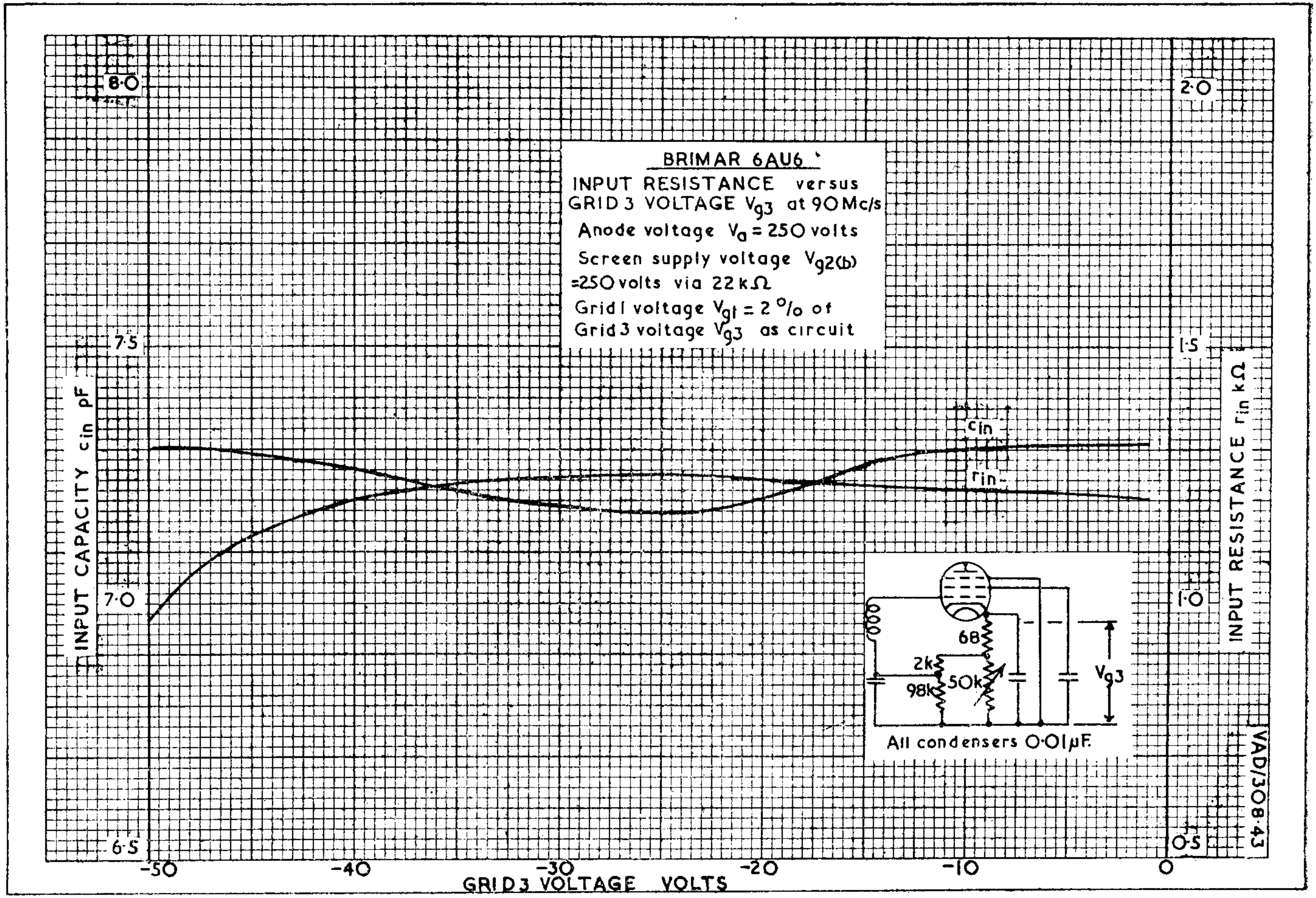

BRIMAR 6AU6
INPUT RESISTANCE & INPUT CAPACITY versus A.V.C. VOLTAGE at 50 Mc/s
Anode voltage $V_a = 250$ volts
Screen supply voltage $V_{g2(b)} = 250$ volts
Screen series resistor = 22 kΩ
Grid 3 voltage $V_{g3} = 0$ volts
INPUT CAPACITY c_{in}, pF
9
8
7
6
INPUT RESISTANCE r_{in} kΩ
24
20
16
12
8
4
0
r_{in}
c_{in}
-8
-7
-6
-5
-4
-3
-2
-1
0
A.V.C. VOLTAGE VOLTS
VAD/308·38

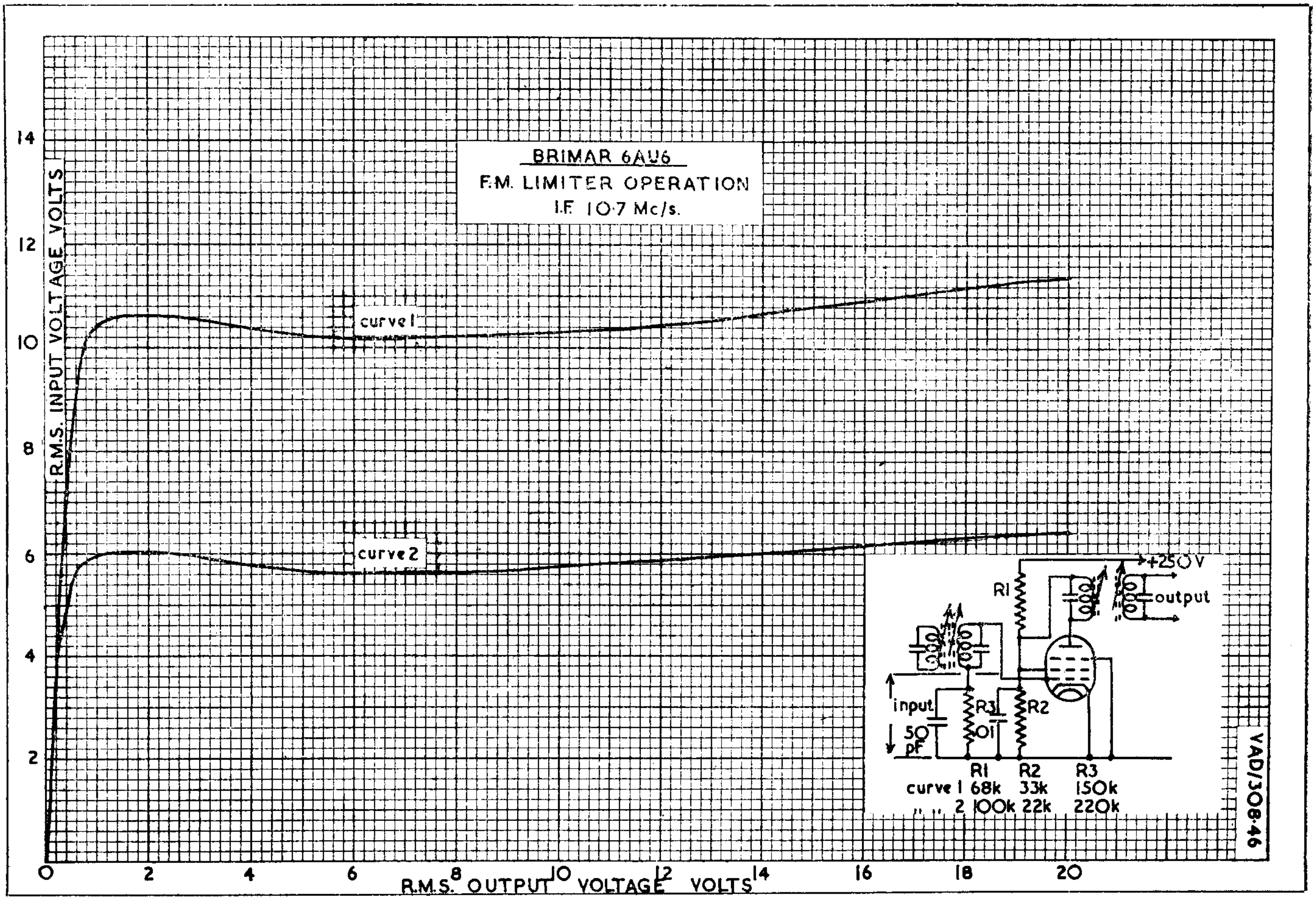

BRIMAR 6AU6
INPUT RESISTANCE versus CATHODE BIAS VOLTAGE at 50 Mc/s
Anode voltage V_a = 250 volts
Screen supply voltage $V_{g2(b)}$ = 250 volts
Screen series resistor = 22kΩ
Grid 3 voltage V_{g3} = 0 volts
INPUT CAPACITY c_{in} pF
INPUT RESISTANCE r_{in} kΩ
CATHODE BIAS VOLTAGE VOLTS
r_{in}
c_{in}
10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


BRIMAR 6AU6
INPUT RESISTANCE versus
GRID 3 VOLTAGE Vg3 at 50Mc/s
Anode voltage Va = 250 volts
Screen supply voltage Vg2(b)
= 250 volts via 22kΩ
Grid 1 voltage Vg1 = 2% of
Grid 3 voltage Vg3 as circuit.
INPUT CAPACITY cin pF
9·0
8·5
8·0
7·5
INPUT RESISTANCE rin kΩ
6
5
4
3
cin
rin
68
2k
50k
98k
Vg3
All condensers 0·01μF
-50
-40
-30
-20
-10
0
GRID 3 VOLTAGE VOLTS
VAD/308·40


BRIMAR 6AU6
INPUT RESISTANCE versus A.V.C VOLTAGE
at 90Mc/s.
Anode voltage V_a =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
INPUT RESISTANCE r_{in} kΩ
c_{in}
r_{in}
A.V.C. VOLTAGE VOLTS
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
6
7
8
1
2
3
4
5
6
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
-8
-7
-6
-5
-4
-3
-2
-1
0
VAD/308·42


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


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