

BRIMAR

RECEIVING VALVE

6AU6

APPLICATION REPORT VAD/508.I

The design of the receiving valve 6AU6 is such that it is not possible to use it without the application of a VAD/508.I.

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Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

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_s and Internal Shield	
	Pin 3 Heater	
	Pin 4 Heater	
	Pin 5 Anode	
	Pin 6 Screen Grid g_s	
	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 g_1 , a	0.0035 pF max.

TRIODE CONNECTED:

c Input	3.1 pF
c Output	1.7 pF
c g_1 , a	2.5 pF

* Measured with no external shield.

GROUNDING 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 $I/100 g_m$ at $V_g = -1$	-4.5	-5.5	-6.35 volts
Suppressor Grid Voltage for $I/100 g_m$ at $V_{g3} = 0$	-38	-81	-90 volts
Equivalent Noise Resistance (R_{eq})	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 $\frac{1.5 \times 1000}{0.54 + 0.27}$ or 1850 ohms. The screen dropping resistor would be $\frac{250 - 50}{0.27}$ or

0.75 megohms. If the grid has a peak AF input of ± 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 $\frac{77}{0.3}$ 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:

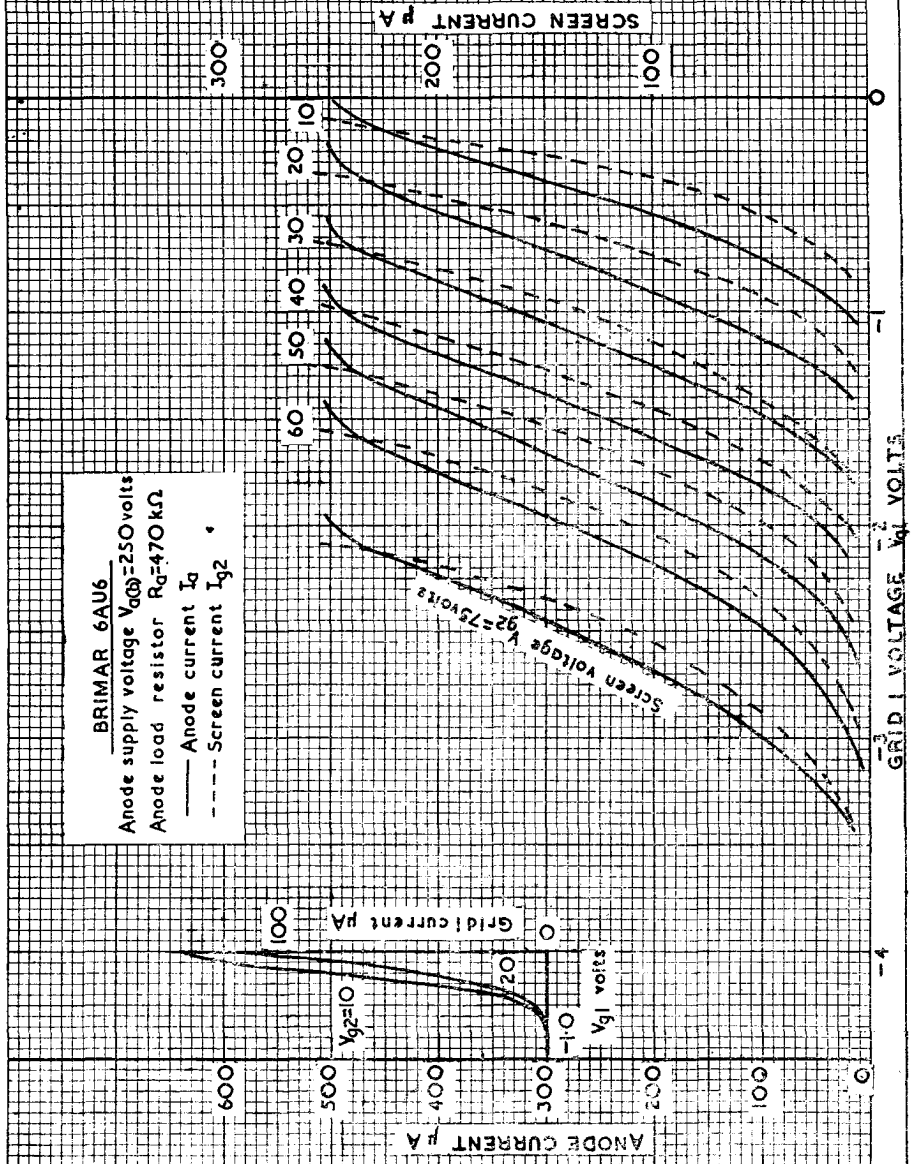
$$\frac{29 \times 150,000}{150,000 + 26,000} = 25$$

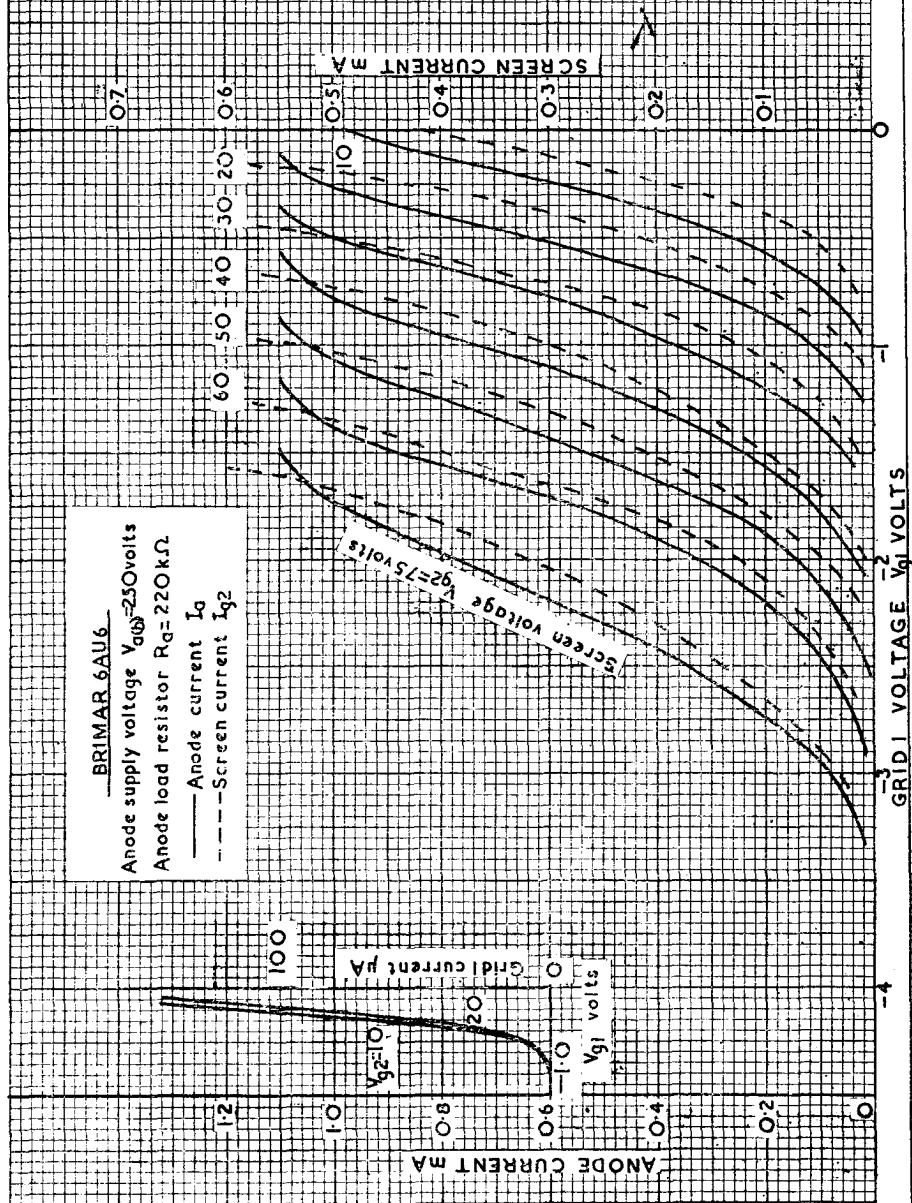
The peak input voltage above was 2.5 volts hence the peak output voltage will be this figure multiplied by the stage gain or 62 volts or 44 volts R.M.S.

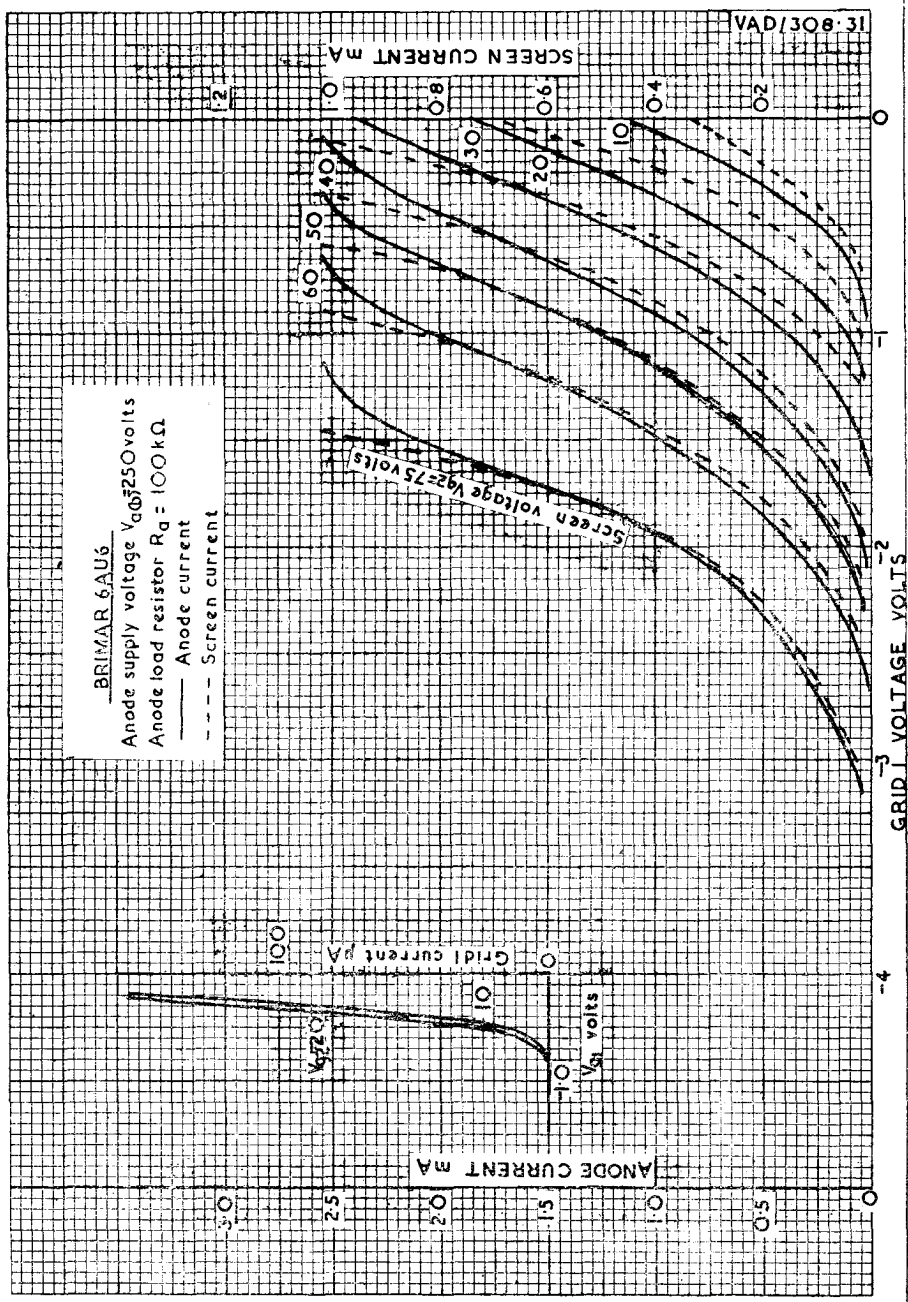
An estimate of the distortion may be made by calculating from the graph as above the stage gain at the extremes of grid bias; in the example the stage gain at —1 volts is 30 and at —6 volts is 20, hence the positive peaks of the signal output will be less than the negative.

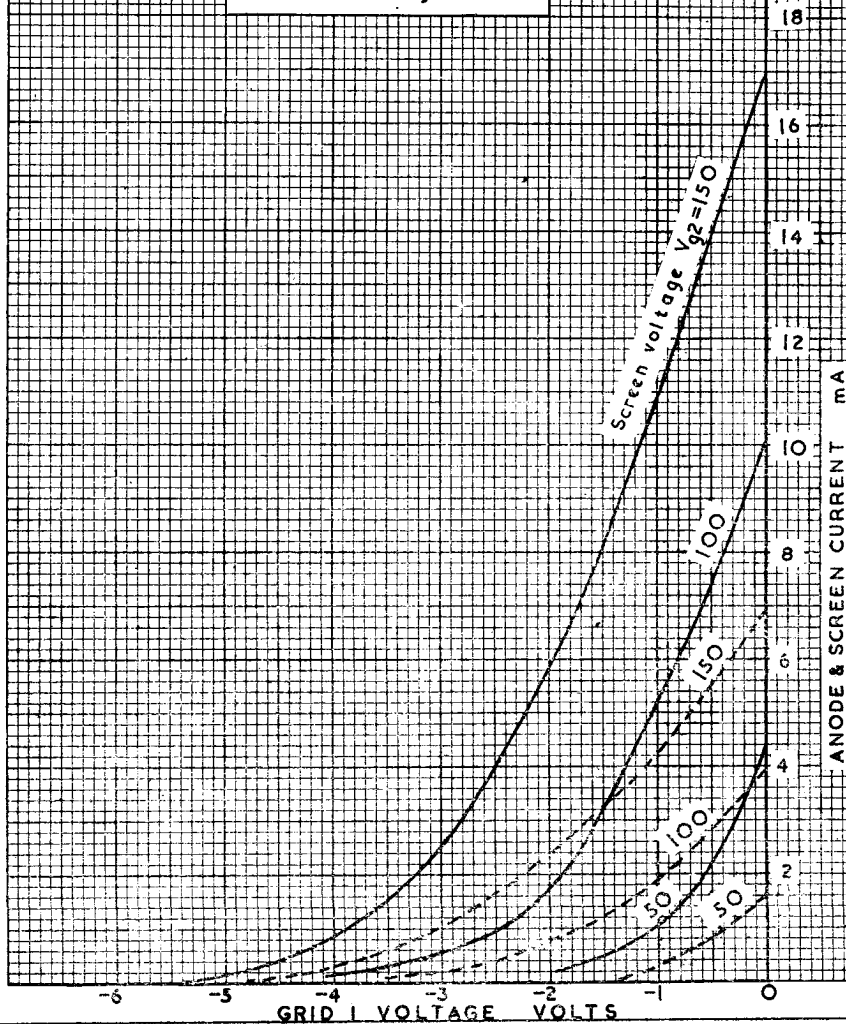
OPERATION AS AN FM LIMITER:

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.







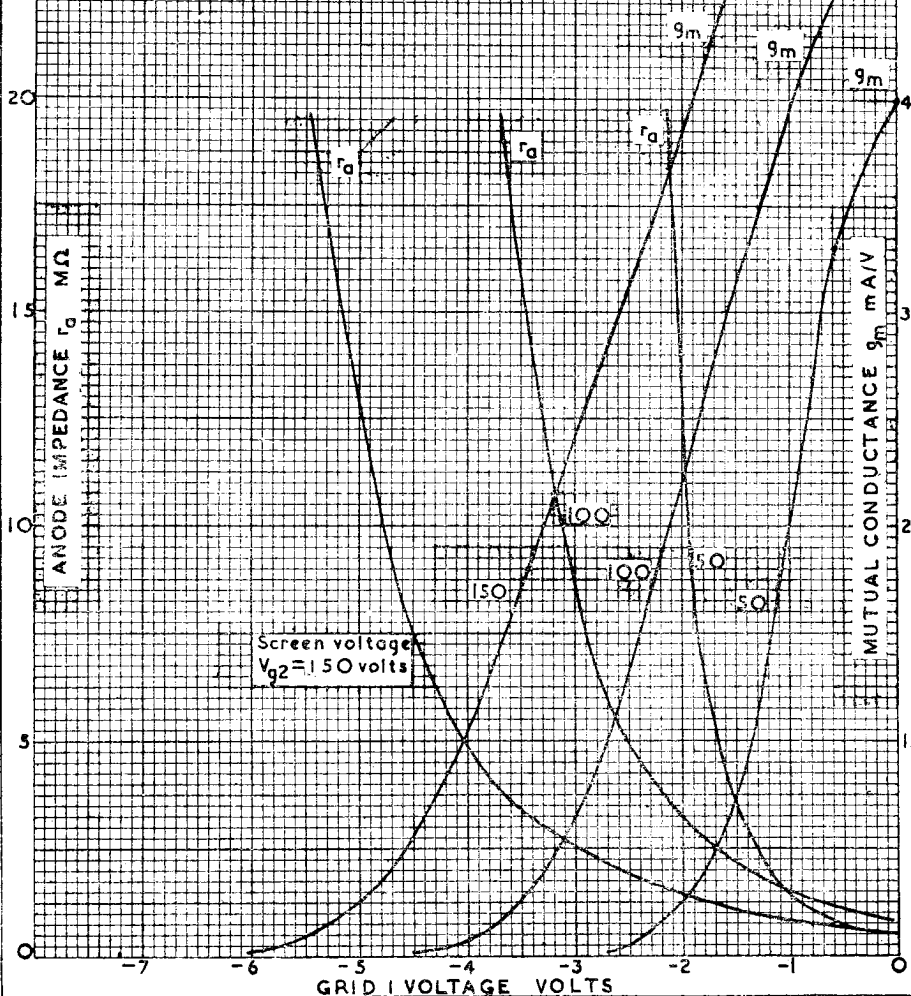
BRIMAR 6AU6ANODE & SCREEN CURRENT
versus GRID 1 VOLTAGE V_{g1} Anode voltage $V_a = 250$ voltsGrid 3 voltage $V_{g3} = 0$ voltsAnode current I_a ———Screen current I_{g2} - - - - -

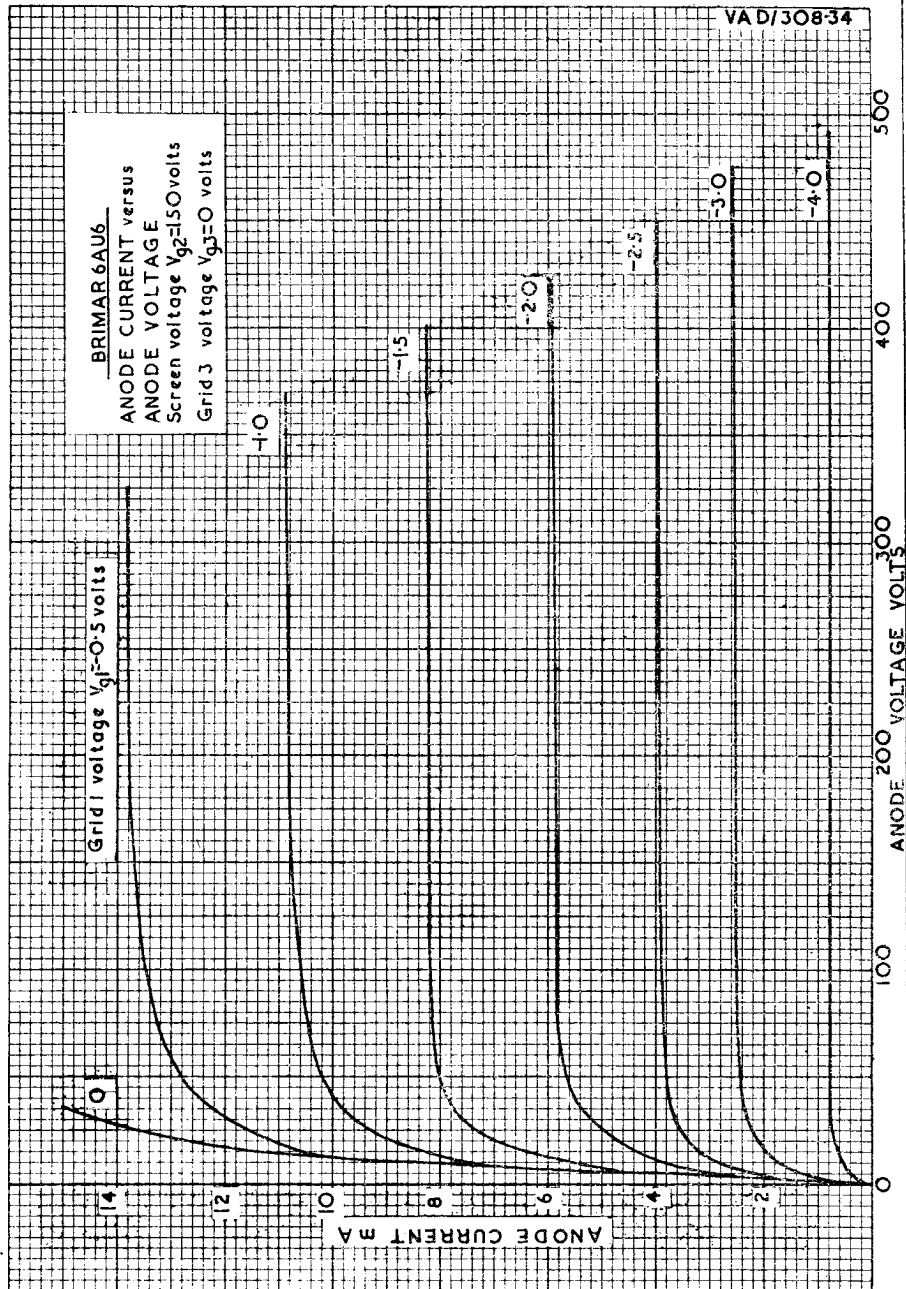
BRIMAR 6AU6

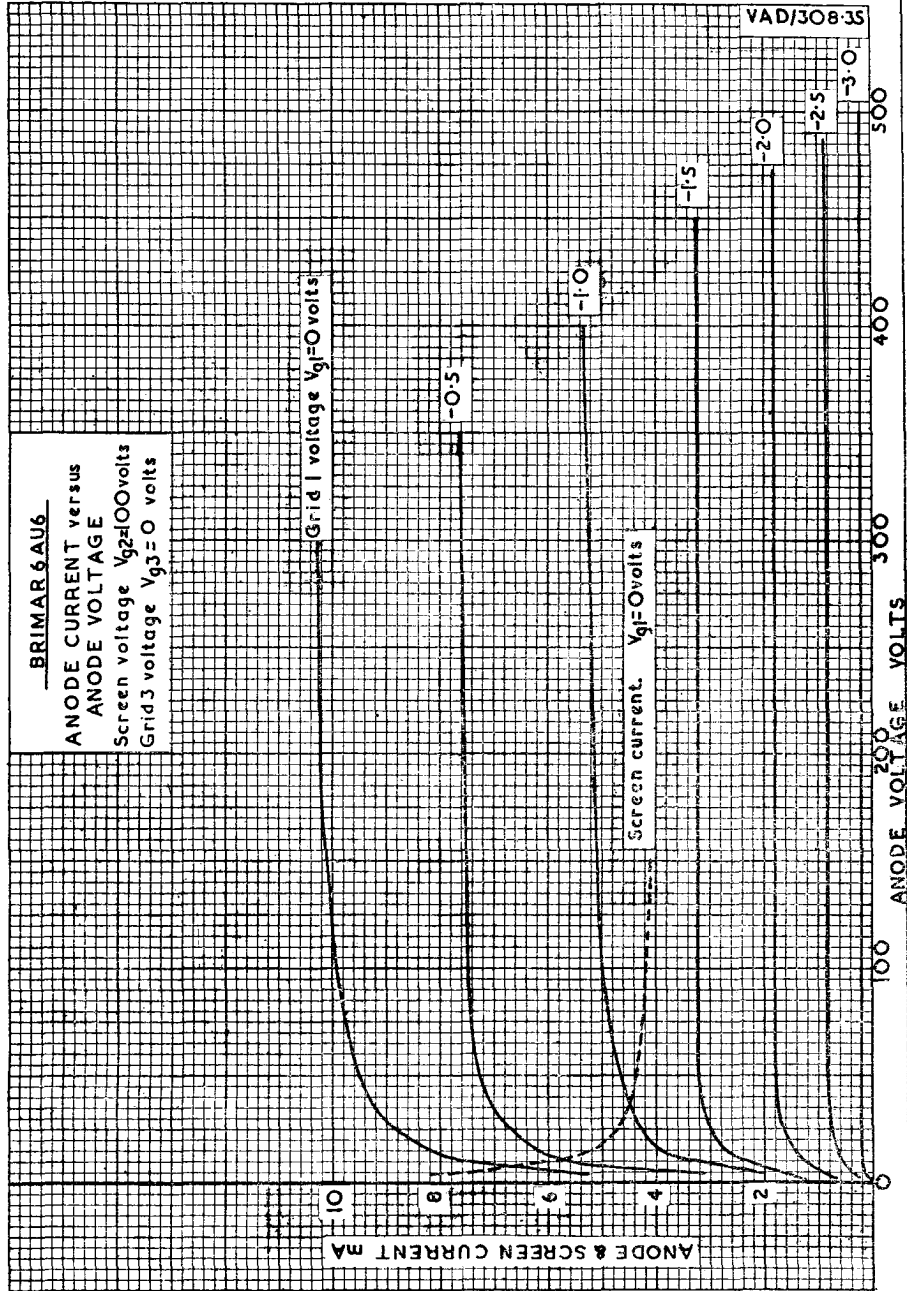
ANODE IMPEDANCE &
MUTUAL CONDUCTANCE
versus GRID 1 VOLTAGE V_{g1}

Anode voltage $V_a = 250$ volts

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







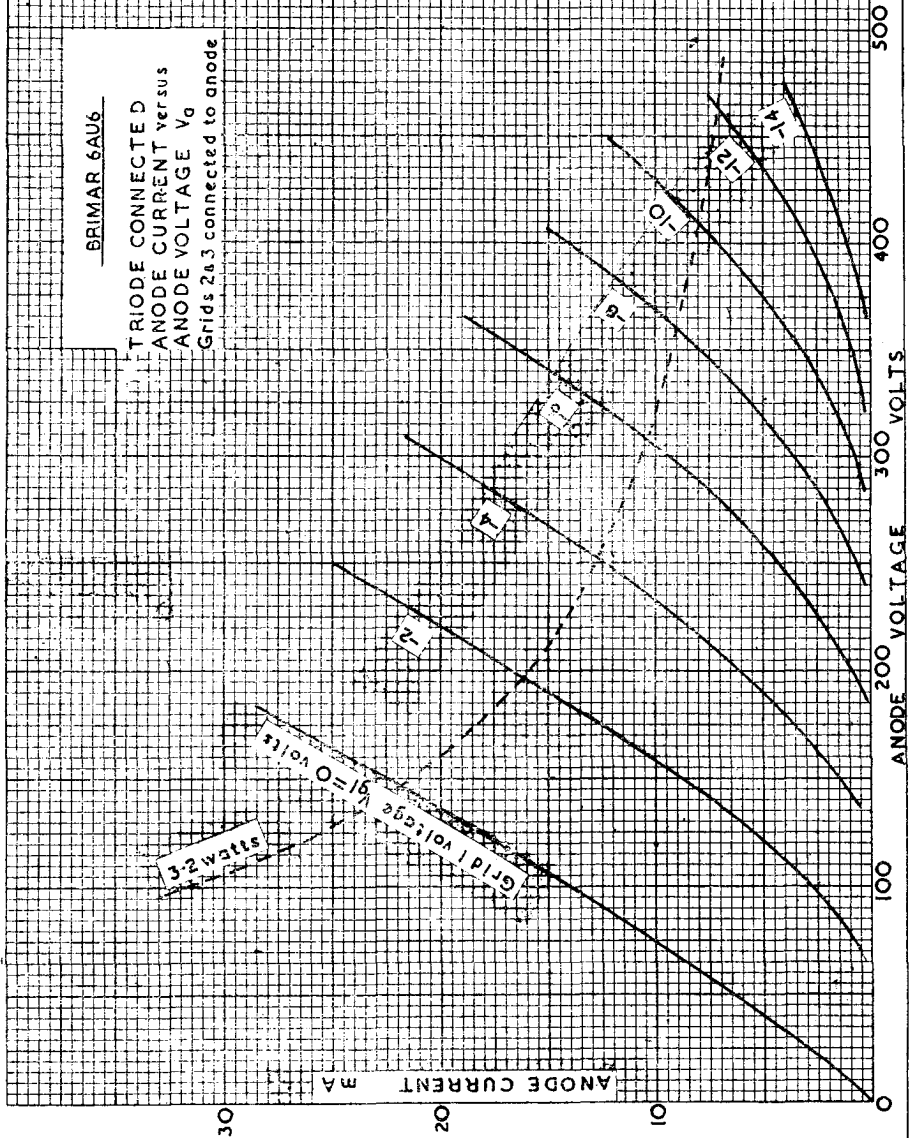
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TRIODE CONNECTED
ANODE CURRENT versus
ANODE VOLTAGE V_a

Grids 2&3 connected to anode

3.2 watts
Grid Voltage $V_g = 0$ volts

Grid Voltage $V_g = 0$ volts



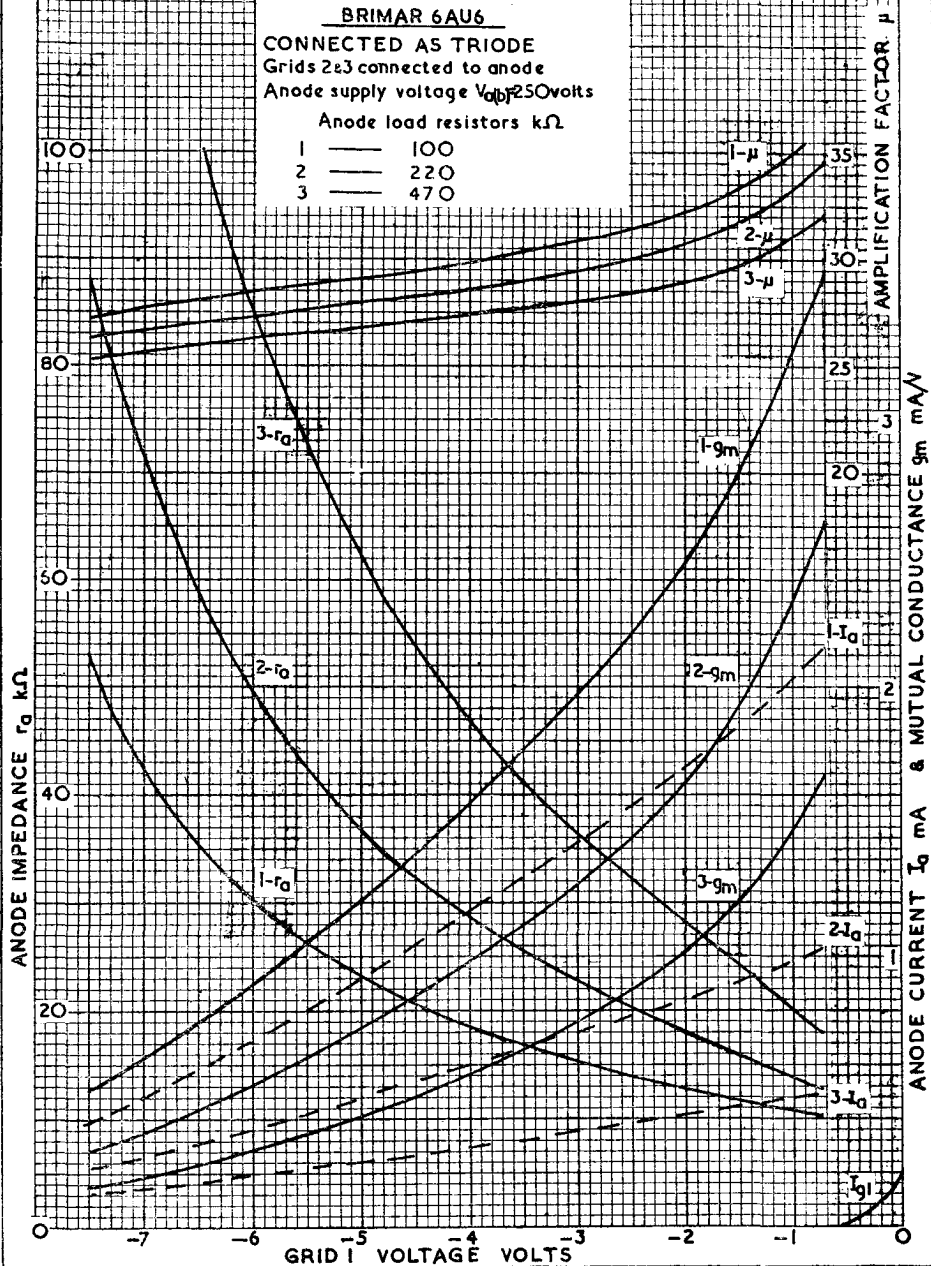
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CONNECTED AS TRIODE

Grids 2 & 3 connected to anode

Anode supply voltage $V_{ab} = 250$ voltsAnode load resistors $k\Omega$

- | | | |
|---|---|-----|
| 1 | — | 100 |
| 2 | — | 220 |
| 3 | — | 470 |



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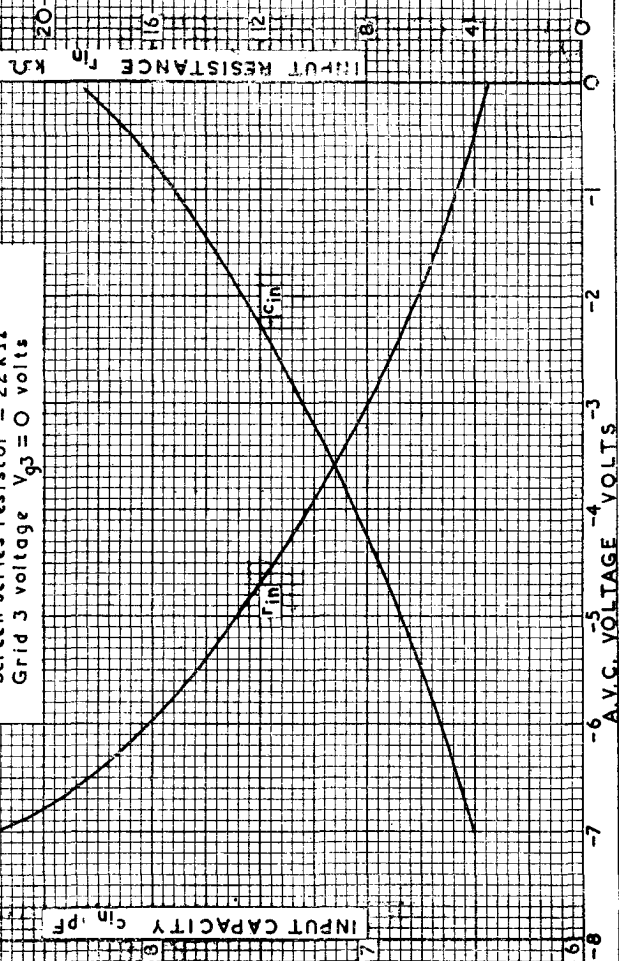
INPUT RESISTANCE & INPUT CAPACITY
versus A.V.C. VOLTAGE at 50 Mc/s

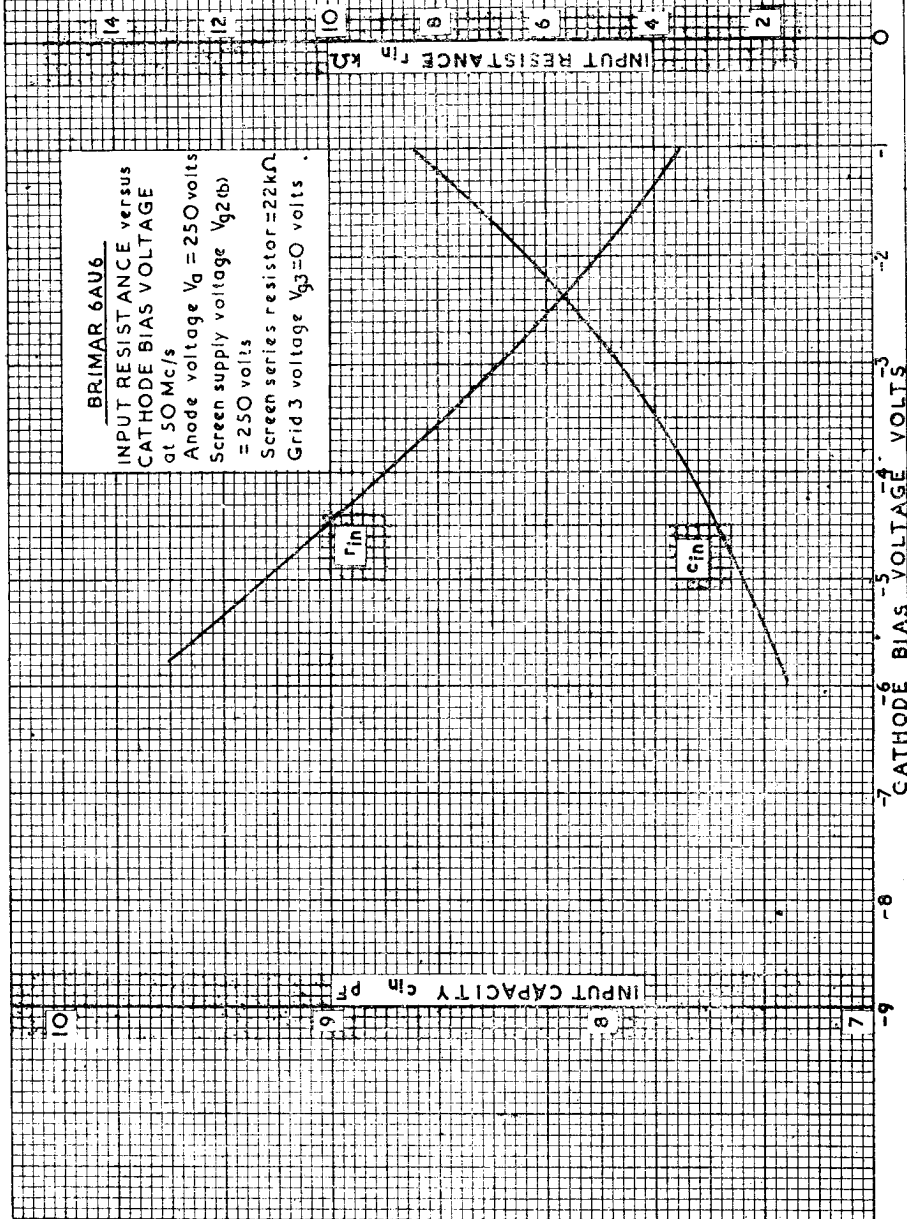
Anode voltage $V_a = 250$ volts

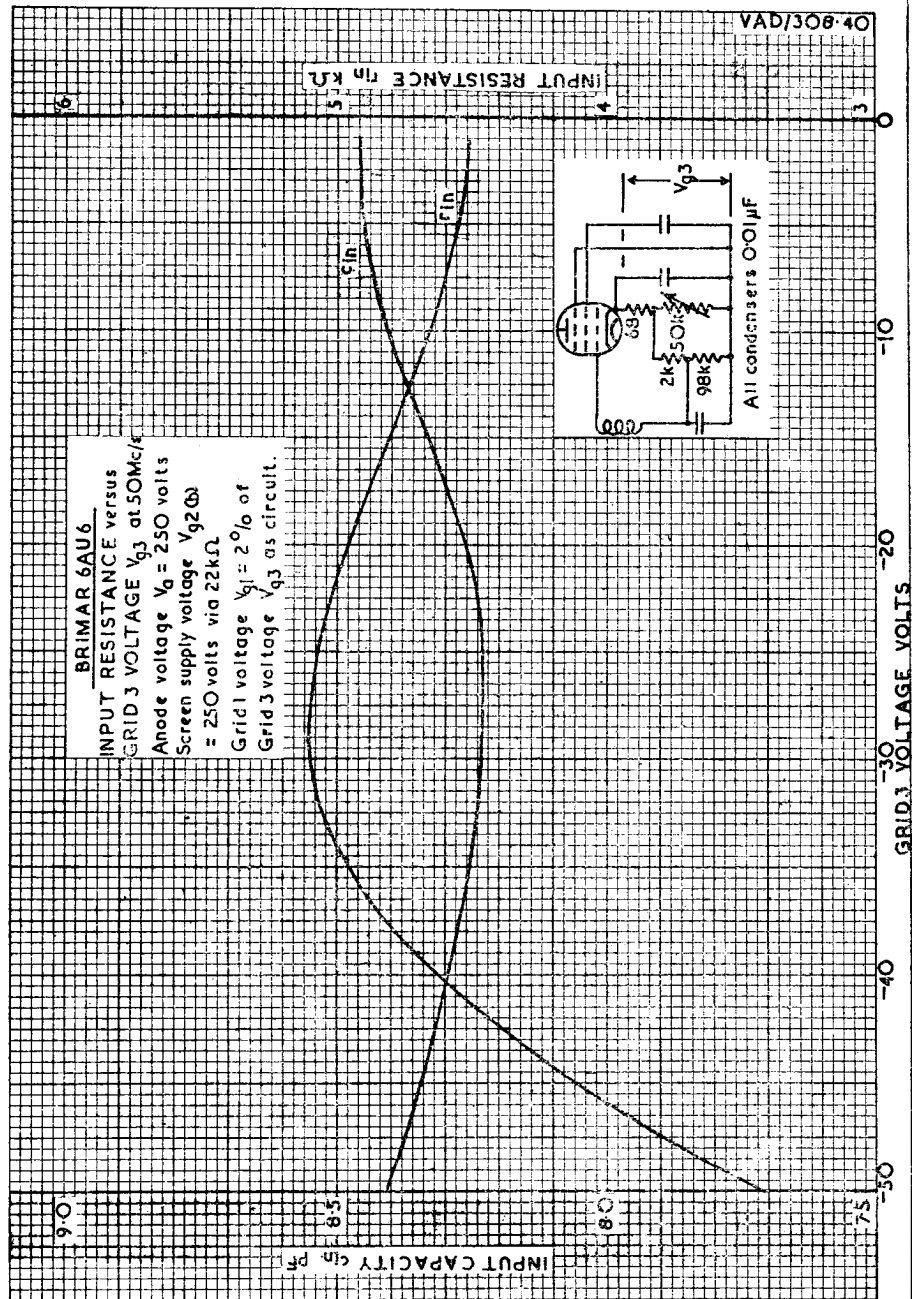
Screen supply voltage $V_{g2} = 250$ volts

Screen series resistor $= 22 \text{ k}\Omega$

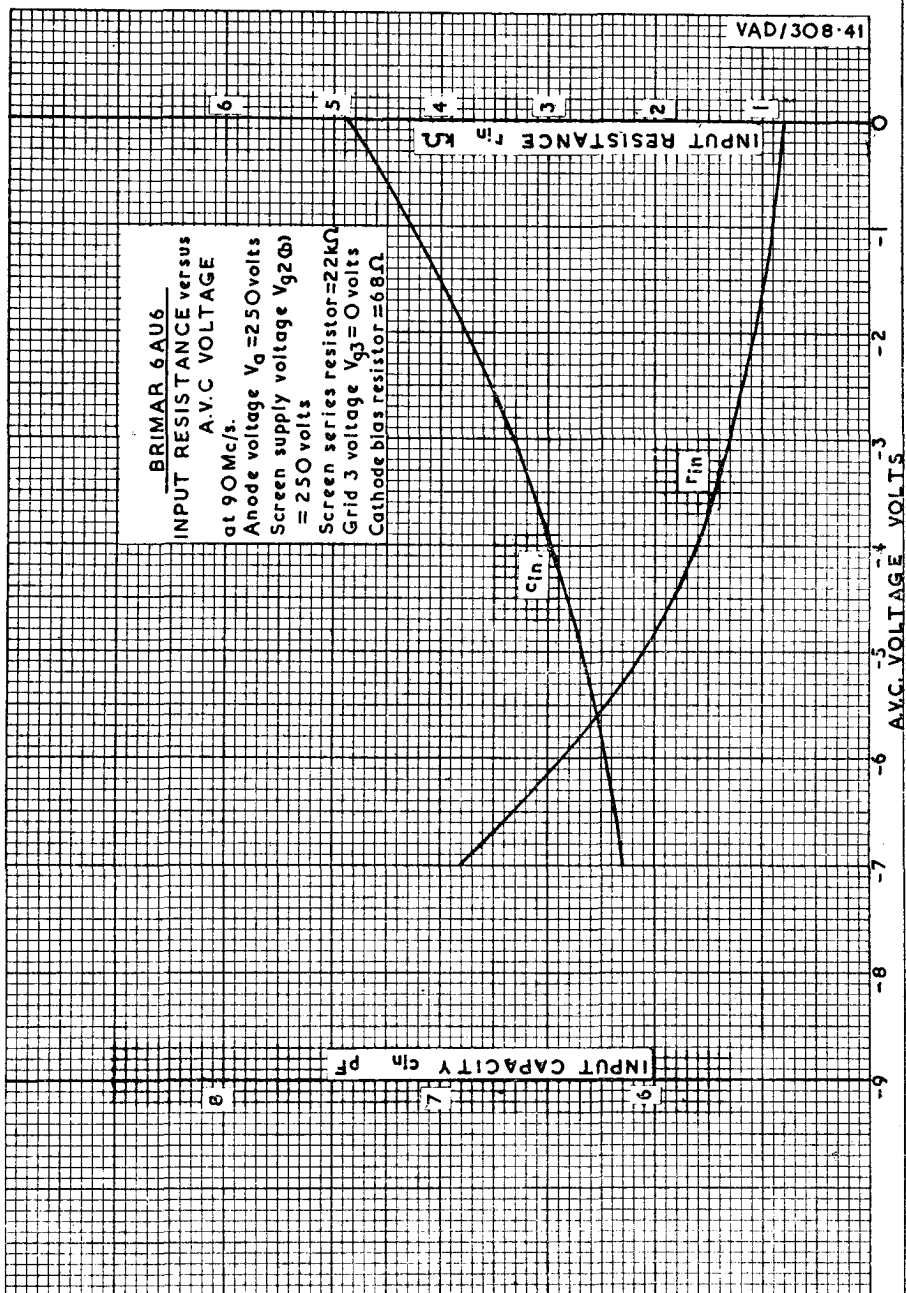
Grid 3 voltage $V_{g3} = 0$ volts







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 INPUT RESISTANCE versus
 A.C. VOLTAGE
 at 90Mc/s.
 Anode voltage $V_a = 250$ volts
 Screen supply voltage $V_{g2} = 250$ volts
 Screen series resistor $= 22k\Omega$
 Grid 3 voltage $V_{g3} = 0$ volts
 Cathode bias resistor $= 68\Omega$



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INPUT RESISTANCE versus
CATHODE BIAS VOLTAGE
at 90 Mc/s.

Anode voltage $V_a = 250$ volts

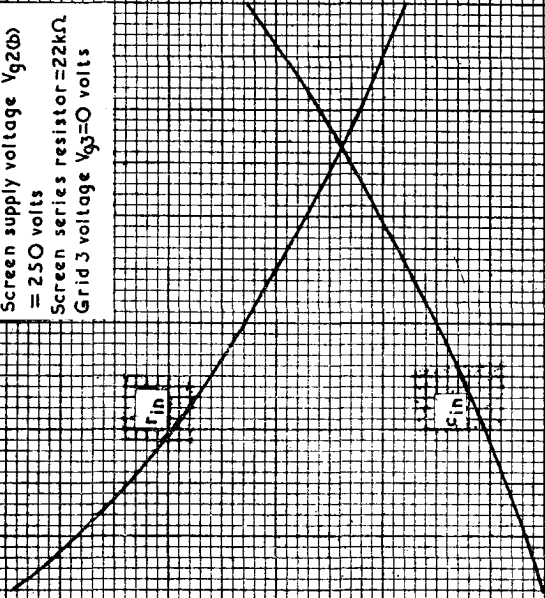
Screen supply voltage $V_{g2(b)} = 250$ volts

Screen series resistor $= 22k\Omega$

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

INPUT RESISTANCE r_{in} K Ω INPUT CAPACITY c_{in} pF

CATHODE BIAS VOLTAGE VOLTS



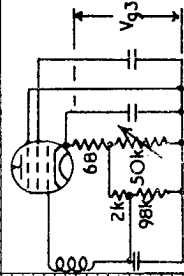
80
PERCENT

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 $22 \text{ k}\Omega$
 Grid 1 voltage $V_{g1} = 2\%$ of
 Grid 3 voltage V_{g3} as circuit

INPUT CAPACITY c_{in} pF

INPUT RESISTANCE r_{in} $\text{k}\Omega$

VAD/308-43



GRID 3 VOLTAGE VOLTS

-50

-40

-30

-20

-10

0

7.5

7.0

2.0

1.5

1.0

0.5

0

14

12

10

8

6

4

2

0

R.M.S. INPUT VOLTAGE VOLTS

BRIMAR 6AU6
F.M. LIMITER OPERATION
IF 10.7 Mc/s.

curve 1

curve 2

R.M.S. OUTPUT VOLTAGE VOLTS

20

16

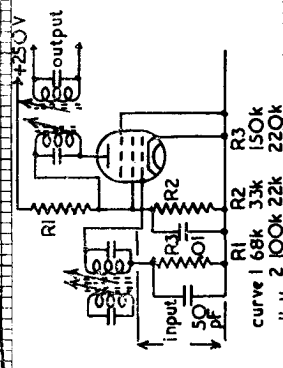
12

8

4

2

0



VAD/308-46