

BRIMAR

RECEIVING VALVE 6CH6

APPLICATION REPORT VAD, 507.9

Standard Telephones and Cables Limited

FOOTSCRAY, KENT, ENGLAND

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 g₃ 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 electron stream. This is because it is not a grid as such but consists of beam confining plates.

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

3.0 CHARACTERISTICS:

3.1 Cathode:	Indirectly heated	
	Voltage	6.3 volts
	Current (Nominal)	0.75 ampere
	Max. DC Heater-Cathode potential	90 volts

3.2 Dimensions:	Max. Overall Length	2.5/8 ins.
	Max. Diameter	7/8 in.
	Max. Seated Height	2.3/8 ins.

3.3 Base: Type B9A (Noval)	Pin 1 Internal Connection IC
	Pin 2 Control Grid g ₁
	Pin 3 Cathode k
	Pin 4 Heater h
	Pin 5 Heater h
	Pin 6 Internal Connection IC
	Pin 7 Anode a
	Pin 8 Screen Grid g ₂
	Pin 9 Suppressor Grid g ₃

3.4 Ratings (Design centre, unless otherwise stated):

PENTODE CONNECTED:

Max. Anode Voltage	275 volts
Max. Screen Voltage	275 volts
Max. Anode Dissipation	12 watts
Max. Screen Dissipation	2.5 watts
Max. DC Cathode Current (Absolute)	65 mA
Max. Peak Cathode Current (Absolute)	1.5 amperes*
Max. Control Grid Circuit Resistance	100,000 ohms†
Max. Bulb Temperature (Absolute)	250° C

TRIODE CONNECTED (g₂ connected to a, g₃ 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 capacitive 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 capacitive impedance at the maximum frequency, and the inductive impedance 1.5 times the capacitive 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:

$$R_a = \frac{1}{2\pi f_{\text{max}} C}$$
$$L = 0.5 C R_a^2$$

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:

$$R_a = \frac{1.5}{2\pi f \text{ max. } C}$$

$$L = 0.67 C R_a^2$$

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:

$$R_a = \frac{1.8}{2\pi f \text{ max. } C}$$

$$L1 = 0.12C R_a^2$$

$$L2 = 0.52C R_a^2$$

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 capacitive 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 k Ω shunted by approximately 15 pF and 25 pF, and No. 307-315 shows the performance with a load of 5 k Ω and similar values of capacitive 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.

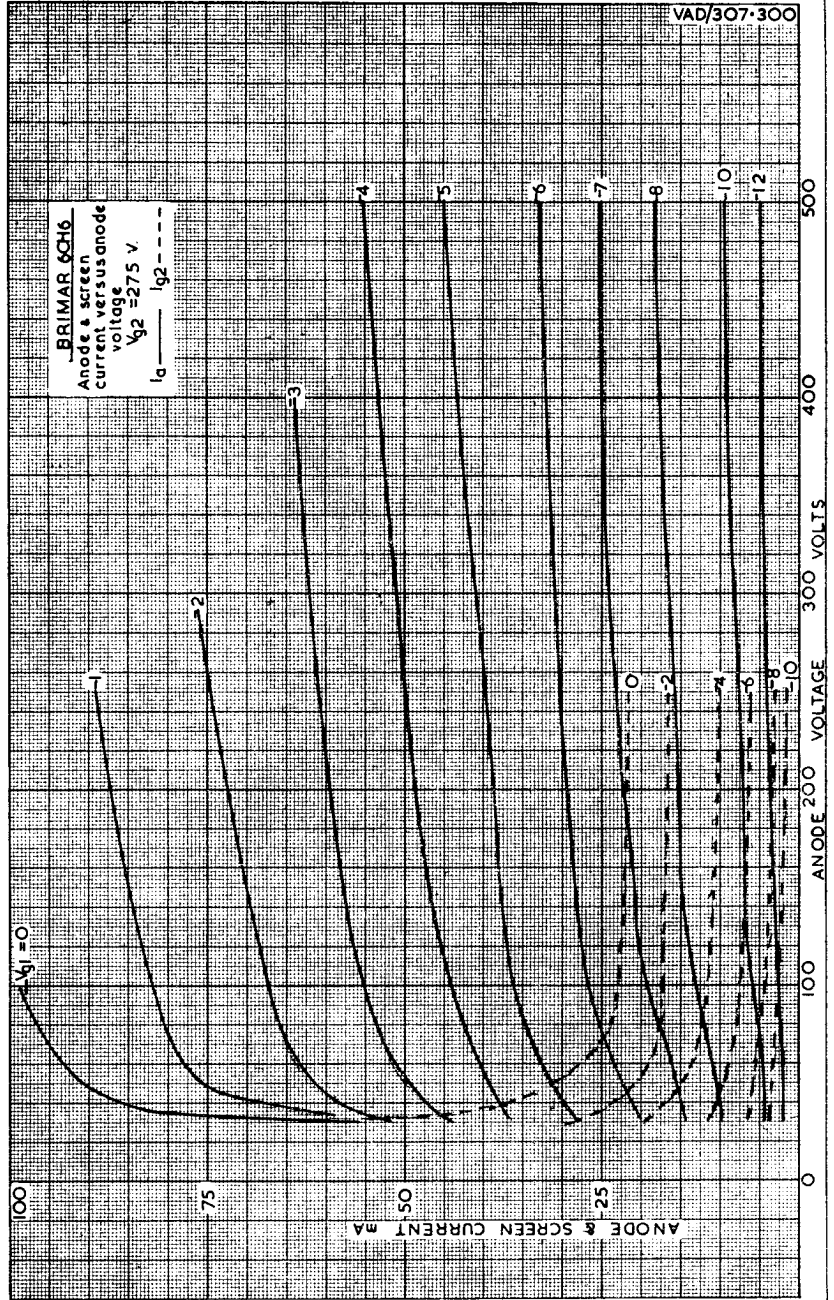
Cathode compensation gives a better low frequency response than anode compensation due to the constant degeneration at low frequencies. The cathode by-pass condenser used with anode compensation, however large, cannot provide effective decoupling at frequencies below 100 c/s.

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.

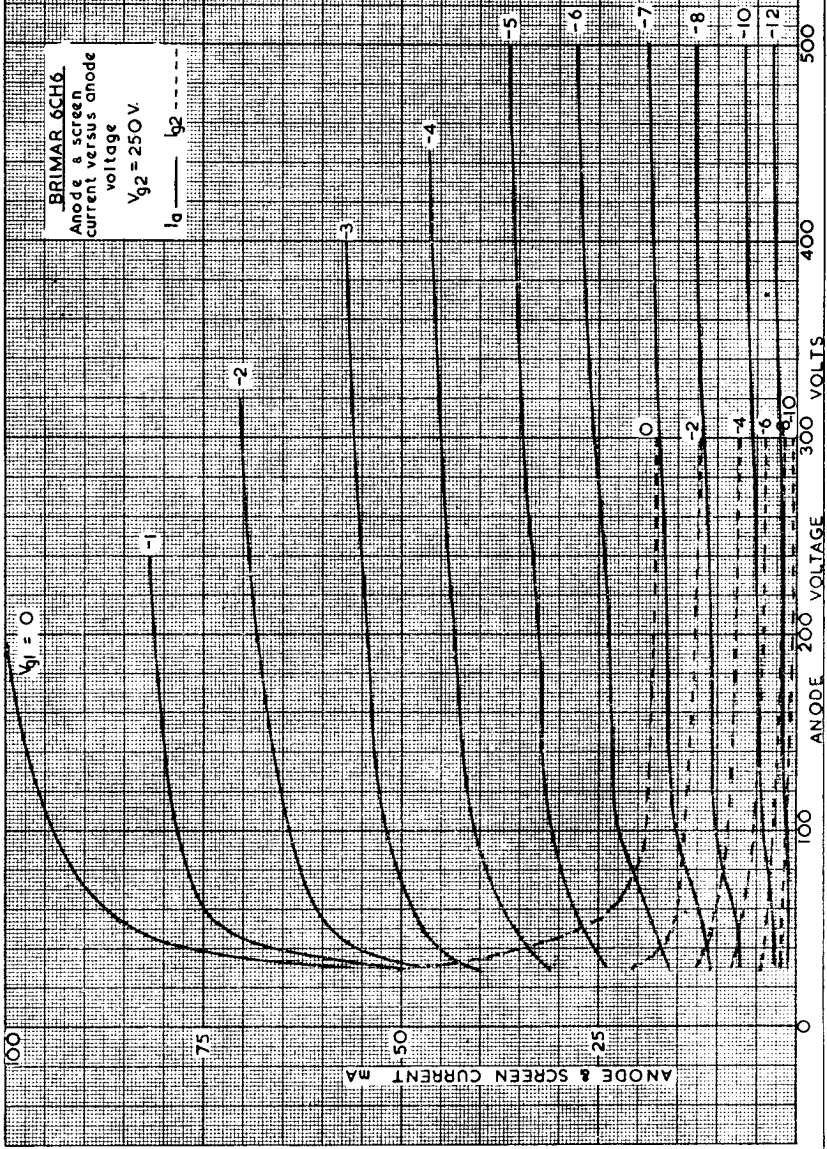
7.0 Cathode Follower: Due to its high slope the 6CH6 is very suitable for a cathode follower stage where a low output impedance is required. Triode connected, the output impedance varies between 60 and 70 ohms depending on the value of cathode resistor employed. With a 250 volt HT supply the cathode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

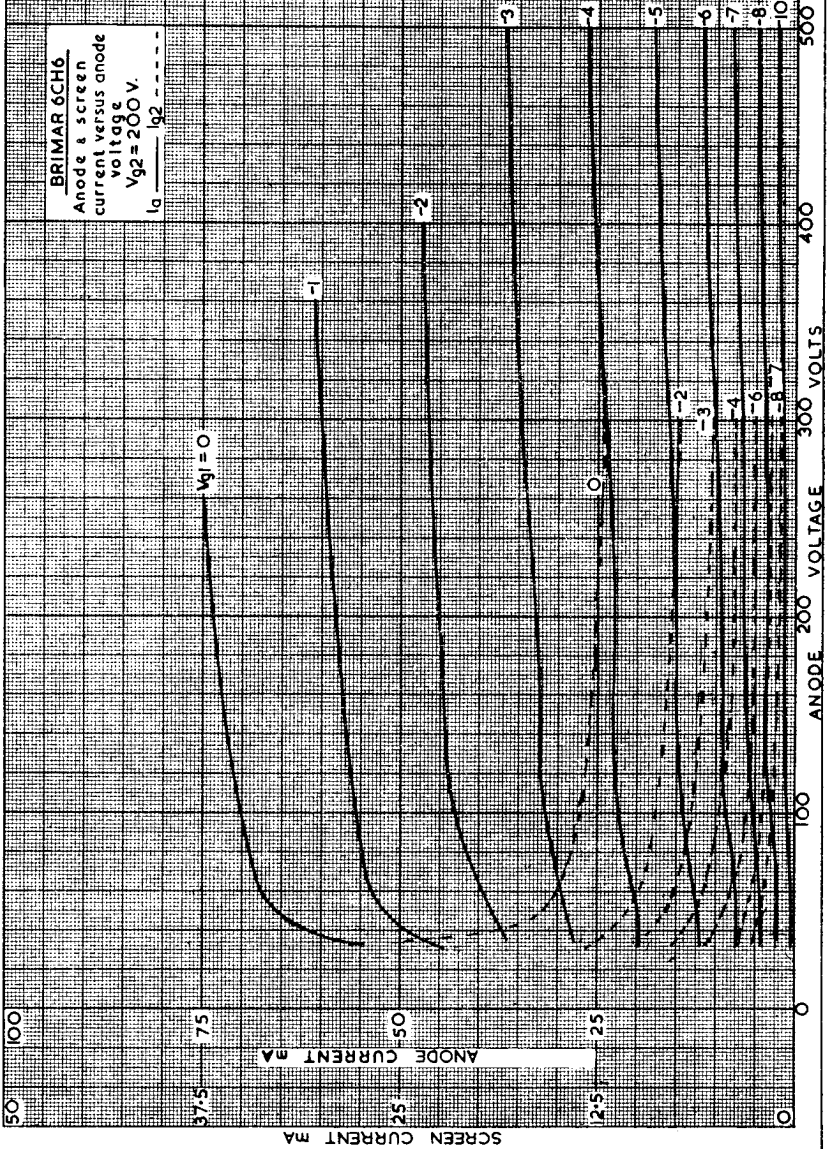
When using the valve with a positively pulsed grid care must be taken not to exceed the ratings given in paragraph 3.4, in particular attention must be paid to the note on grid dissipation.



BRIMAR 6CH6
Anode & screen
current versus anode
voltage
 $V_{g2} = 250 \text{ V}$
 I_a ——— I_{g2} - - - - -



BRIMAR 6CH6
Anode & screen
current versus anode
voltage
 $V_{g2} = 200 \text{ V}$
 I_a _____ g_2 -----

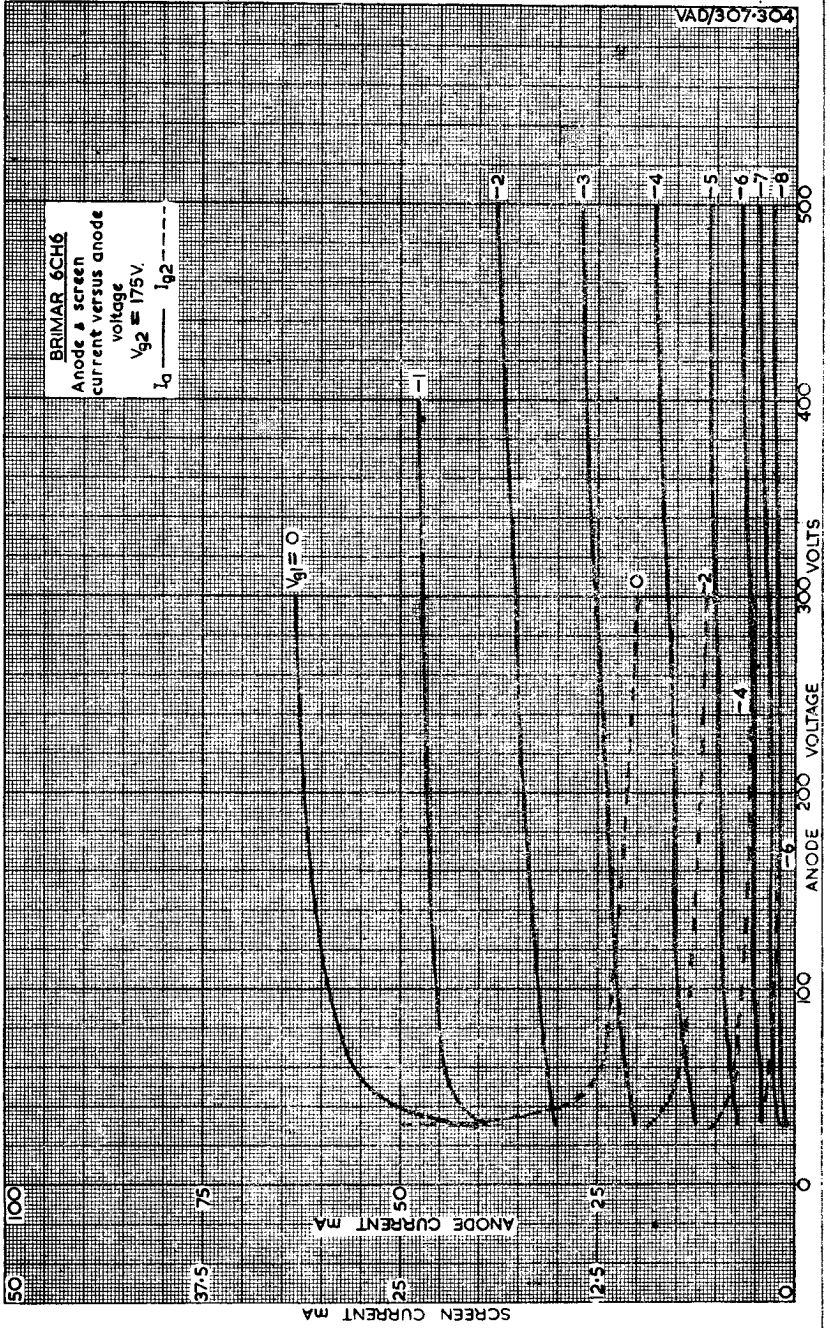


SCREEN CURRENT mA

ANODE CURRENT mA

ANODE VOLTAGE VOLTS

BRIMAR 6CH6
Anode & screen
current versus anode
voltage
 $V_{g2} = 175V$
 I_{g1} ----- I_{g2} -----



SCREEN CURRENT MA

ANODE CURRENT MA

ANODE VOLTAGE VOLTS

BRIMAR 6CH16
Anode & screen
current versus anode
voltage
 $V_{g2} \approx 150V$
 I_a ——— I_{g2} - - - -

$V_{g1} = 0$

50

37.5

25

12.5

0

ANODE & SCREEN CURRENT MA

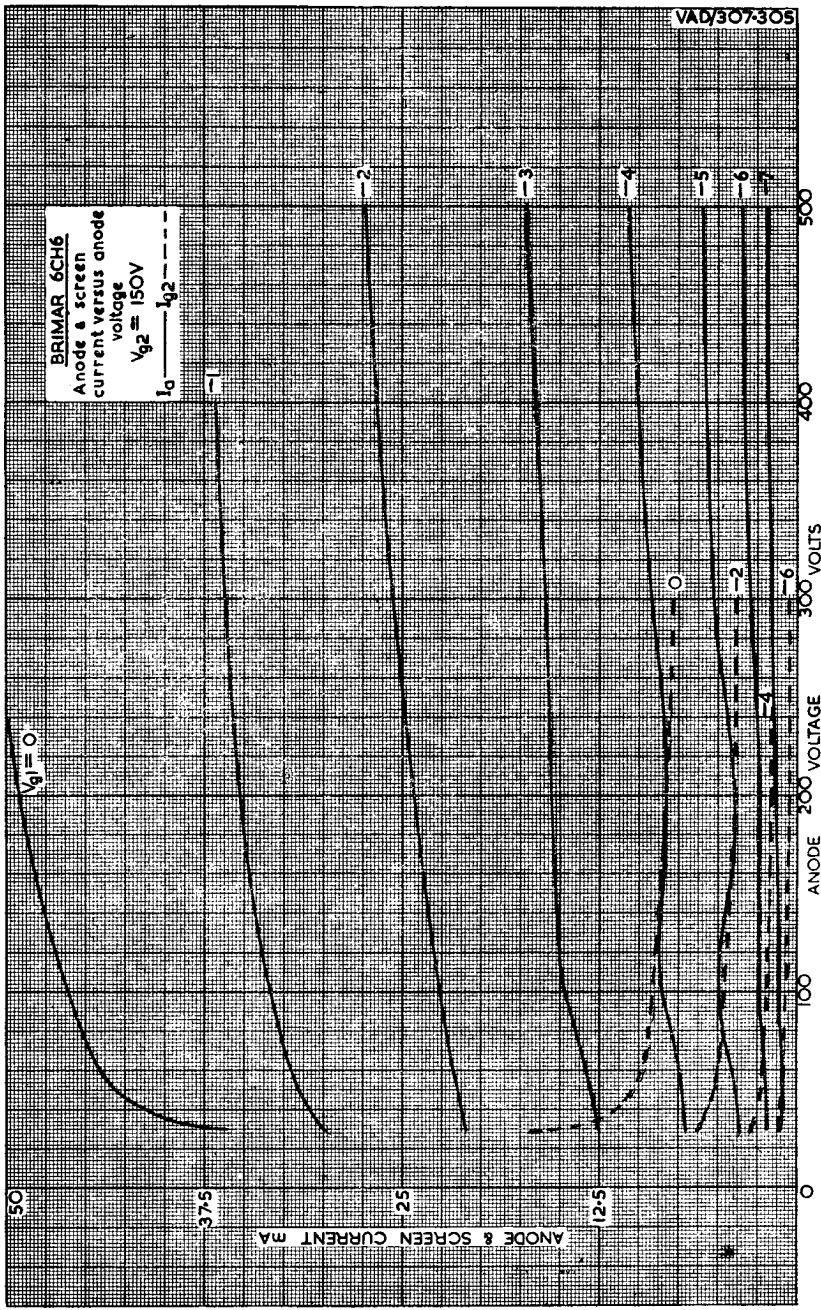
500

400

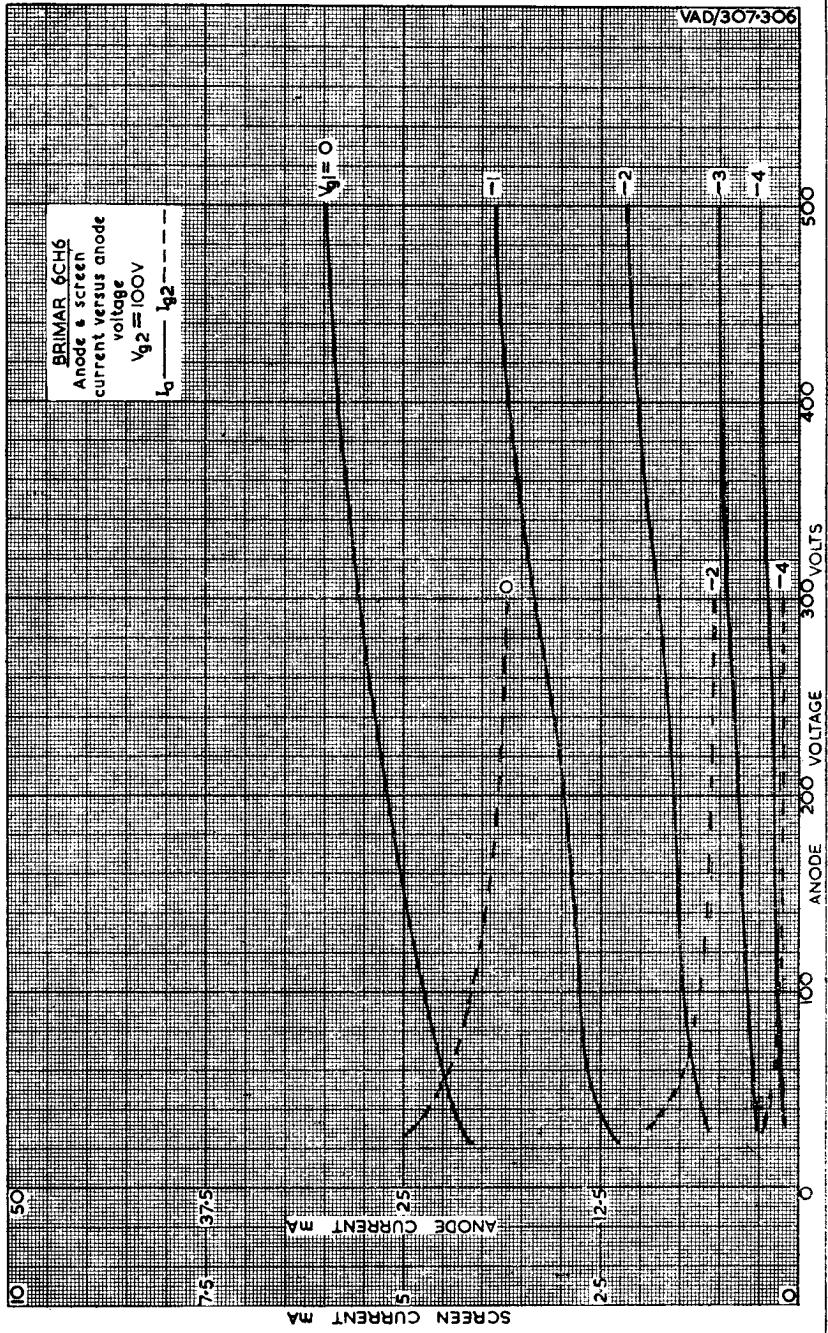
300 VOLTS

200 VOLTS

ANODE



BRIMAR 6CH6
Anode & screen
current versus anode
voltage
 $V_{g2} = 100V$
 I_0 ——— I_{g2} - - - -



SCREEN CURRENT MA

ANODE CURRENT MA

0 50

7.5 37.5

15 25

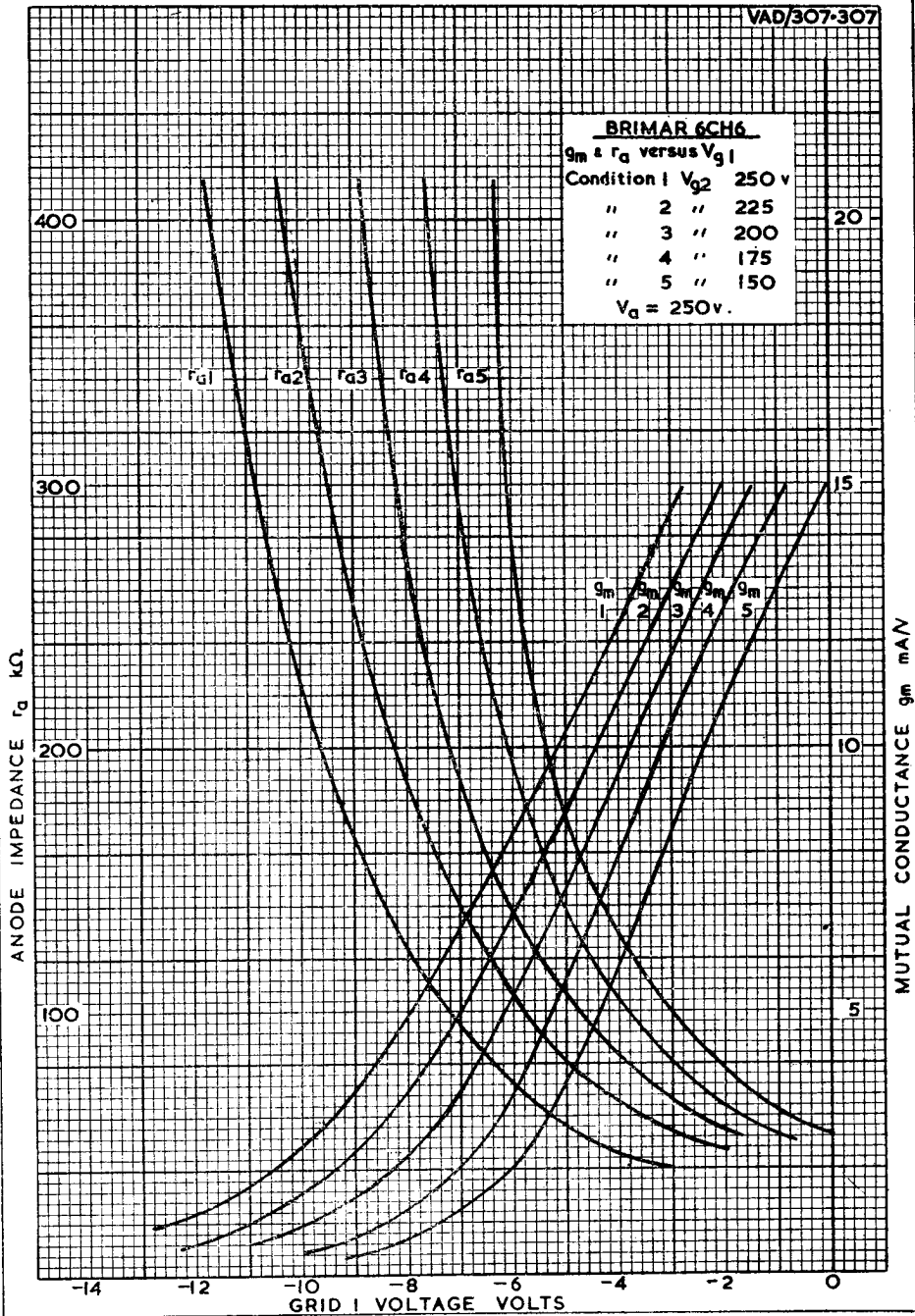
22.5 12.5

0

ANODE VOLTAGE

0 100 200 300 400 500 VOLTS

BRIMAR 6CH6		
g_m & r_a versus V_{g1}		
Condition	V_{g2}	V_a
"	2	225
"	3	200
"	4	175
"	5	150
$V_a = 250v.$		

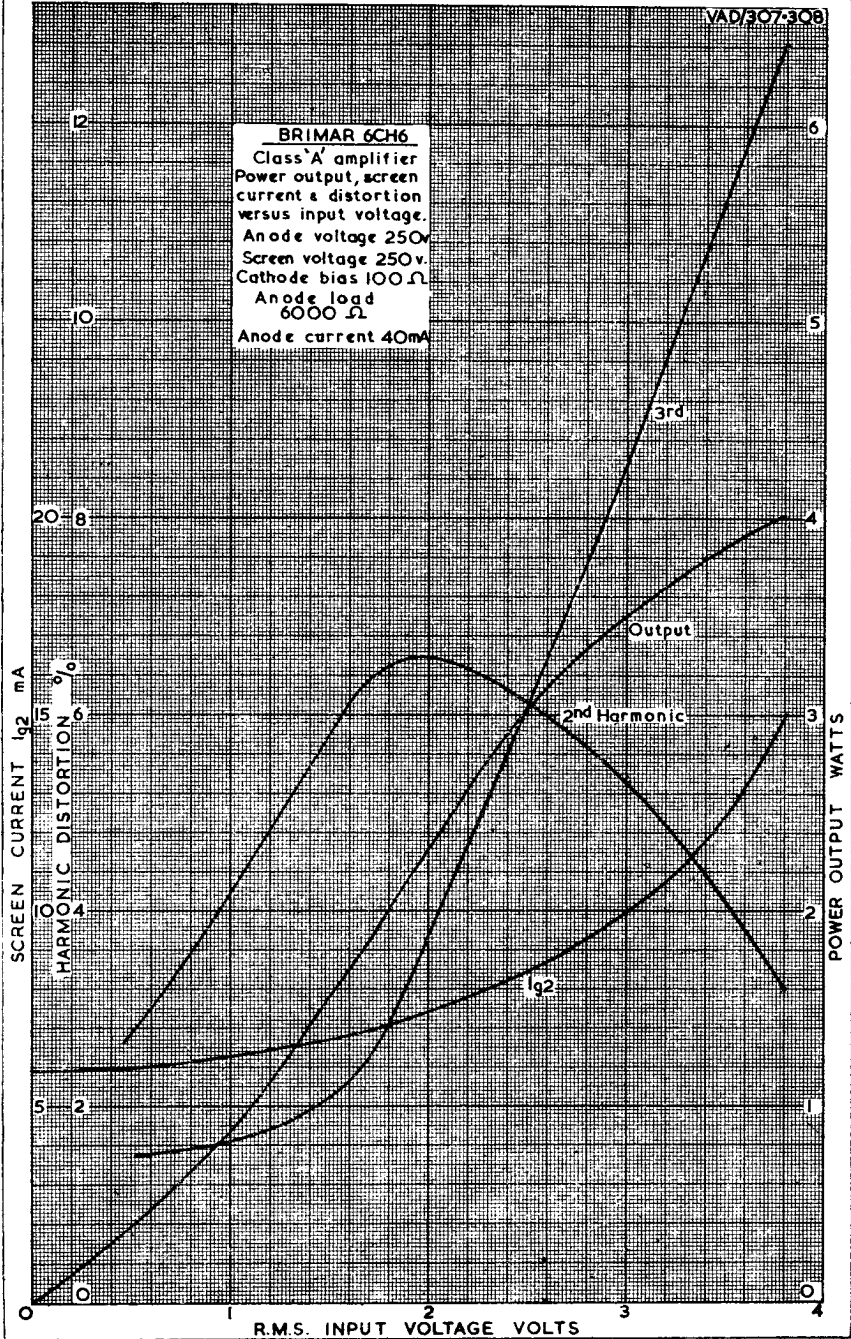


ANODE IMPEDANCE r_a k Ω

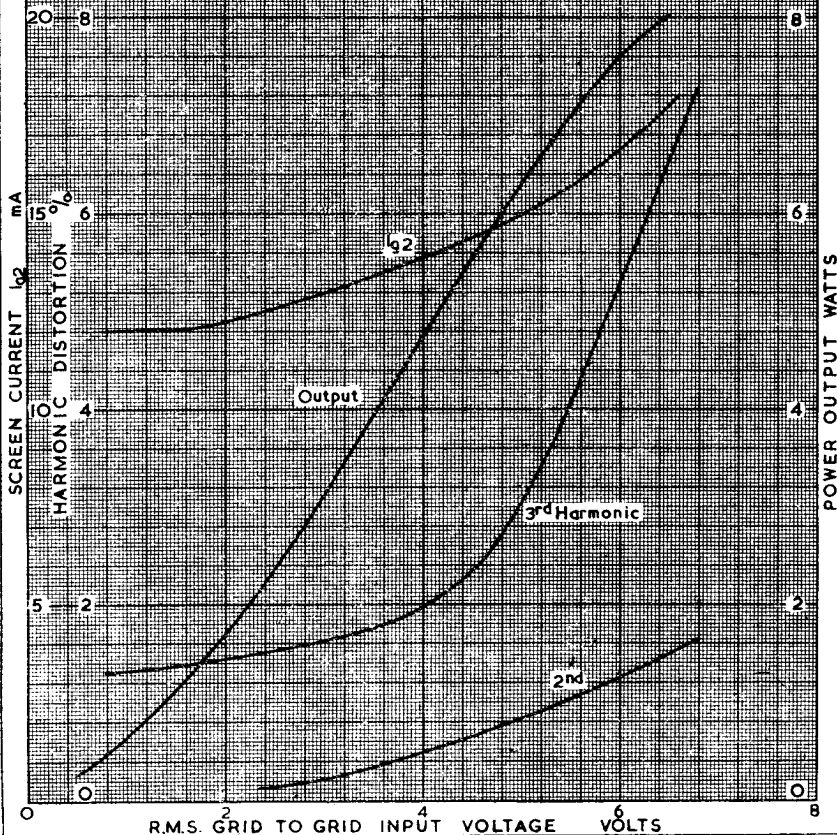
MUTUAL CONDUCTANCE g_m mA/V

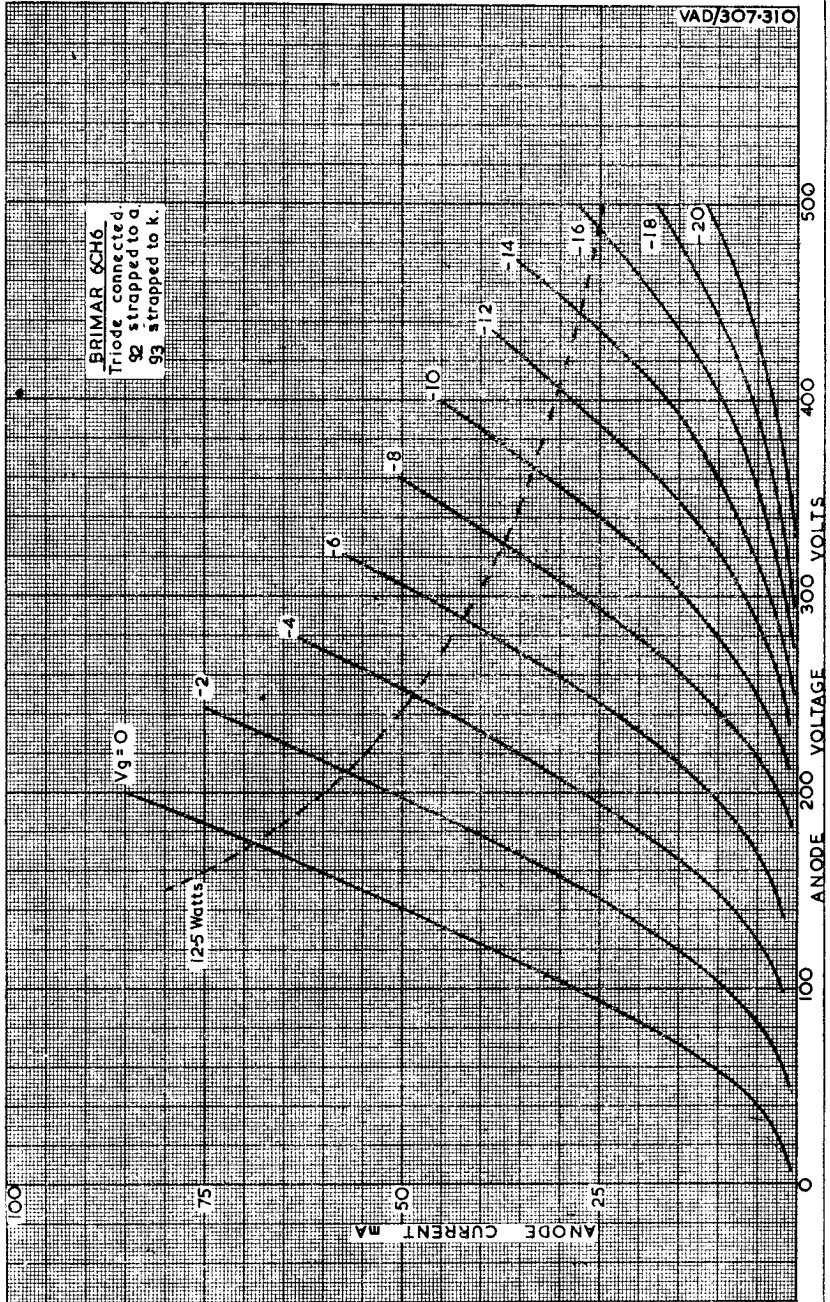
GRID 1 VOLTAGE VOLTS

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



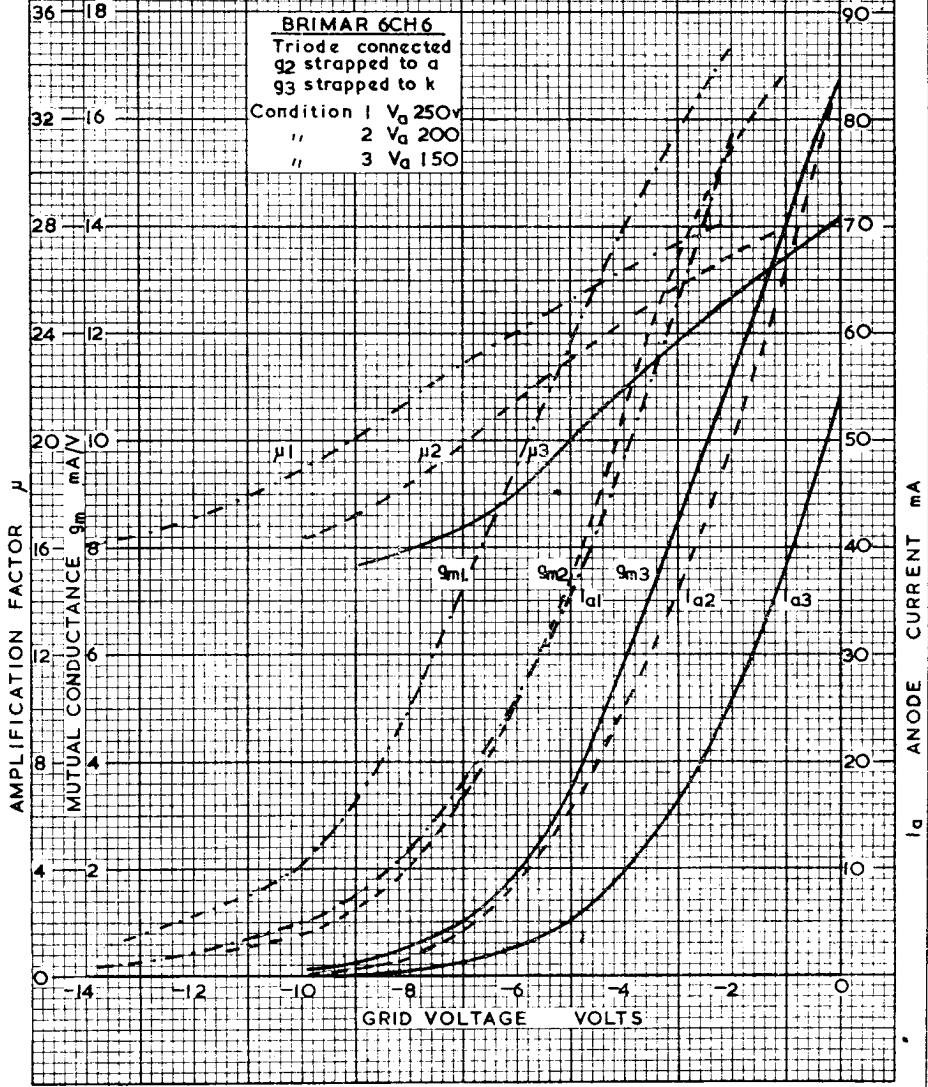
BRIMAR 6CH6
 Class A push-pull
 Power output, screen
 current & distortion
 versus input voltage.
 Anode voltage 250 v.
 Screen voltage 250 v.
 Cathode bias 50 Ω .
 Anode to anode load
 9,000 Ω .





BRIMAR 6CH6
 Triode connected
 g2 strapped to a
 g3 strapped to k

Condition 1	V_a 250V
" 2	V_a 200
" 3	V_a 150



BRIMAR 6CH6

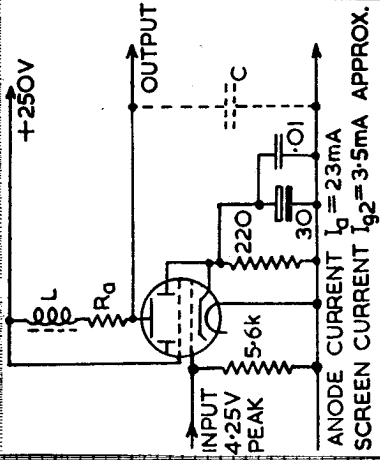
ANODE COMPENSATED VIDEO AMPLIFIER

Anode load resistor $R_a = 1k\Omega$

1 — C = 15pF, L = 13μH.

2 — C = 25pF, L = 16μH.

3 — C = 35pF, L = 27μH.

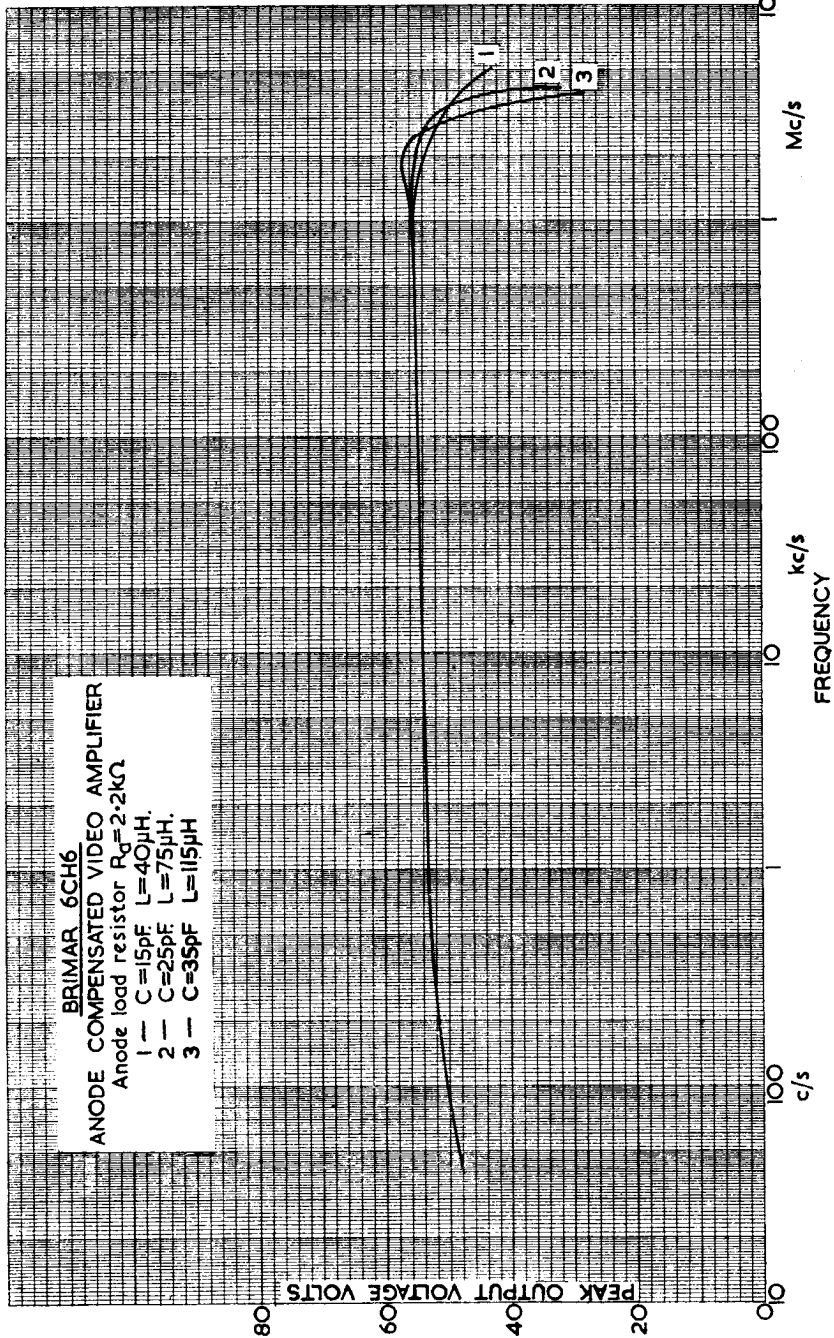


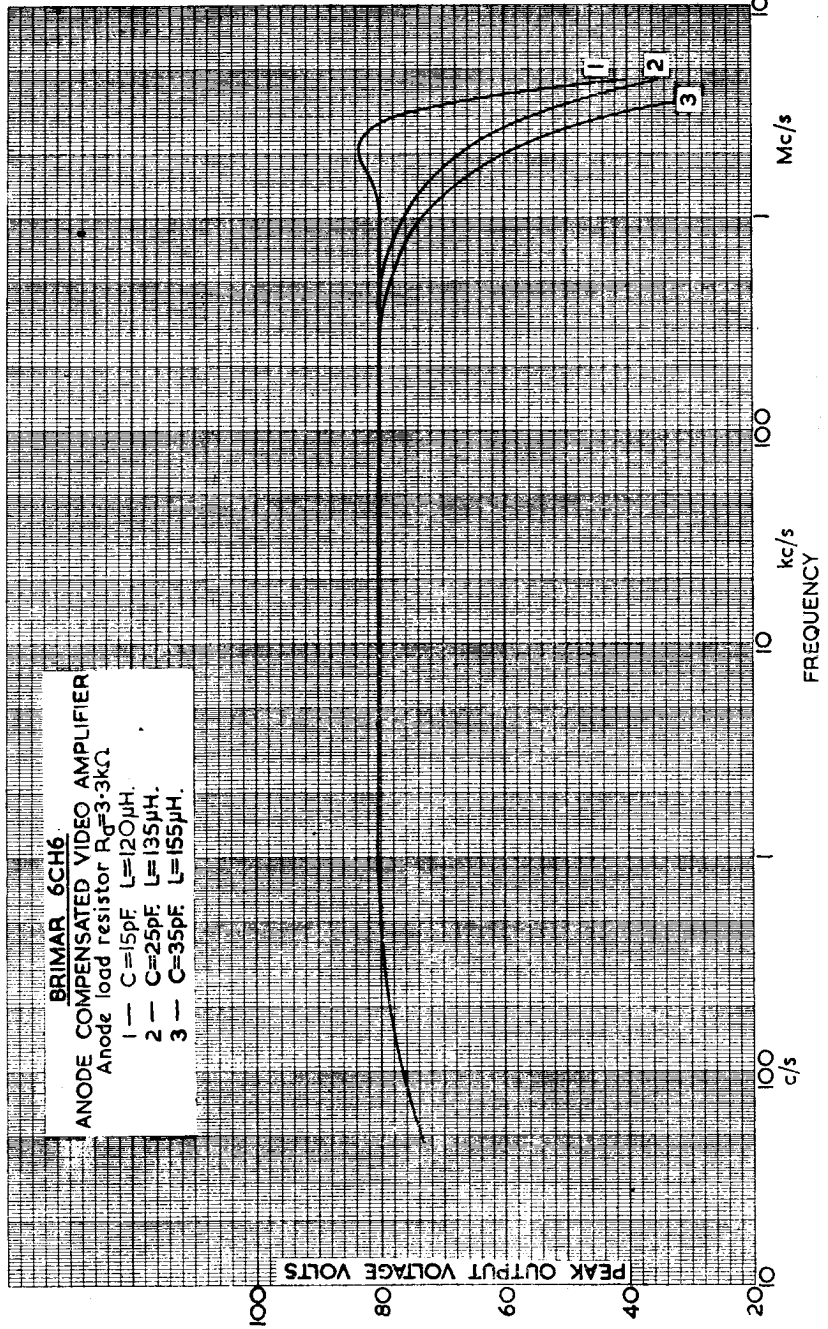
ANODE CURRENT $I_a = 23\text{mA}$
 SCREEN CURRENT $I_{g2} = 3.5\text{mA}$ APPROX.

1,2 & 3

PEAK OUTPUT VOLTAGE VOLTS

FREQUENCY
 c/s
 kc/s
 Mc/s





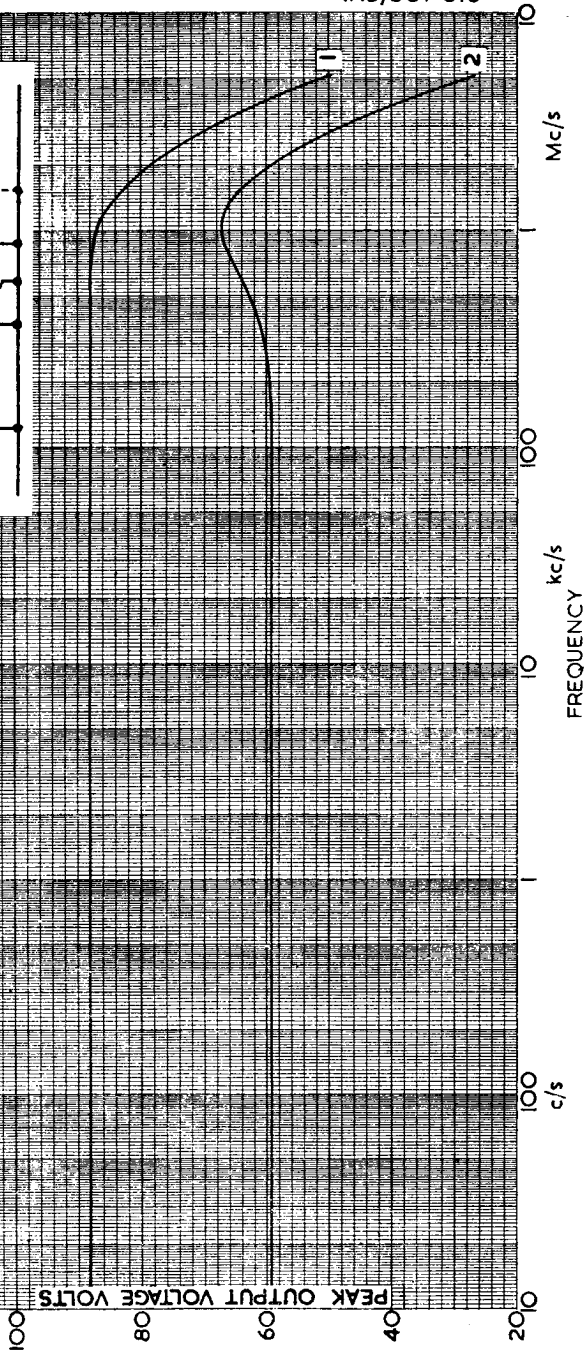
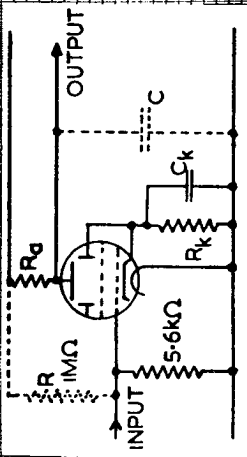
BRIMAR 6CH6
CATHODE COMPENSATED VIDEO
AMPLIFIER

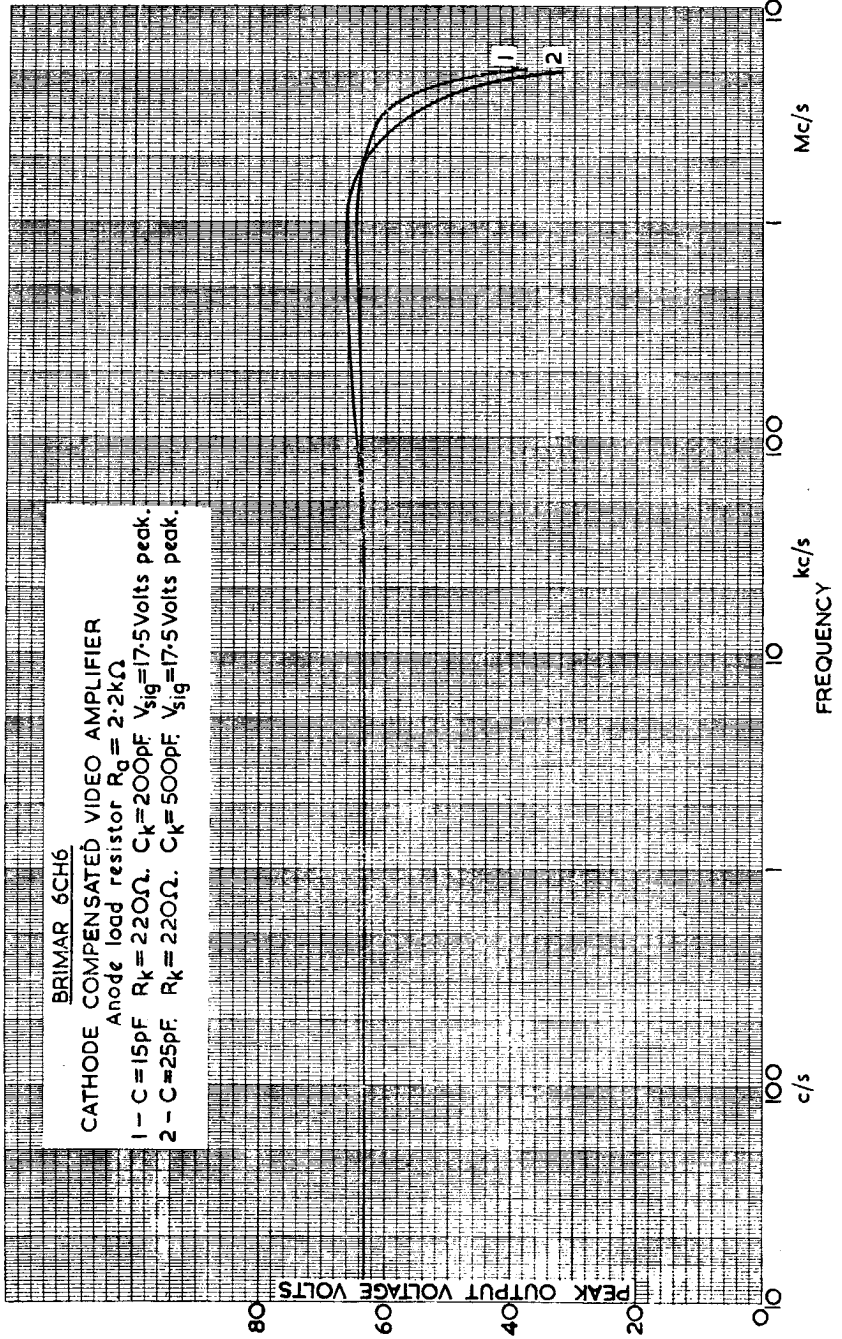
Anode load resistor $R_d = 5k\Omega$

1 - C = 15pF. $R_k = 330\Omega$. $C_k = 500pF$. $V_{sig} = 12$ Volts peak

2 - C = 25pF. $R_k = 680\Omega$. $C_k = 800pF$. $V_{sig} = 16.5$ Volts peak

Positive bias resistor R only used for condition 2





BRIMAR 6CH6
 ANODE, CONTROL GRID & SCREEN
 CURRENTS versus ANODE VOLTAGE
 Screen voltage $V_{g2} = 250$ Volts
 Suppressor voltage $V_{g3} = 0$ Volts

I_a —————
 I_{g1} - - - - -
 I_{g2} - - - - -

