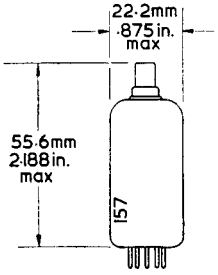
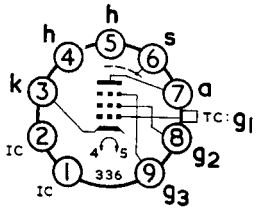


LOW MICROPHONY AMPLIFIER PENTODE



B9A Base, CTI Cap

GENERAL

This valve is a screened pentode intended for use where low A.F. noise, microphony and hum are required, as in early stages of high gain A.F. amplifiers. The control grid is brought out to a top cap to reduce stray pick-up in the valve. Used under suitable conditions this valve will operate satisfactorily at input levels as low as 10μV on its grid.

Heater Voltage	V_h	6·3	V
Heater Current	I_h	0·15	A

RATINGS

PENTODE CONNECTED

Maximum Anode Voltage	$V_{a(max)}$	300*	500†	V
Maximum Screen Voltage	$V_{g2(max)}$	125*	300†	V
Maximum Anode Dissipation	$P_{a(max)}$	0·75		W
Maximum Screen Dissipation	$P_{g2(max)}$	0·3		W

TRIODE CONNECTED

Maximum Anode Voltage	$V_{a(max)}$	250		V
Maximum Anode Dissipation	$P_{a(max)}$	1·75		W

* At I_a = 5·8mA.
† At I_a = 0mA, I_{g_2} = 0mA.

INTER-ELECTRODE CAPACITANCES

PENTODE CONNECTED

Input	C_{in}	4	pF
Output	C_{out}	4	pF
Control Grid to Anode	$C_{g1\text{-}a}$	0·01	pF

TRIODE CONNECTED

Input	C_{in}	3	pF
Output	C_{out}	6·7	pF
Control Grid to Anode	$C_{g\text{-}a}$	1·1	pF

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TYPICAL OPERATION

PENTODE CONNECTED (g_3 connected to k)				
Anode Voltage	V_a	100	250	V
Screen Grid Voltage	V_{g2}	100	100	V
Control Grid Voltage	V_{g1}	−3	−3	V
Cathode Bias Resistor	R_k	1·1	1·1	kΩ
Anode Current	I_a	2	2·1	mA
Screen Current	I_{g2}	0·7	0·6	mA
Anode Resistance ($\delta v_a/\delta i_a$)	r_a	1·5	2·4	MΩ
Mutual Conductance	g_m	1·1	1·25	mA/V
Inner Amplification Factor	μ_{g1-g2}	20	20	
Control Grid Voltage for $g_m/100$ at $V_{g1} = -3V$	V_{g1}	−8	−9	V
Equivalent Noise Resistance	R_{eq}	10·25	7·25	kΩ

TRIODE CONNECTED (g_2 connected to a, g_3 connected to k)				
Anode Voltage	V_a	250		V
Control Grid Voltage	V_{g1}	−8		V
Anode Current	I_a	6·5		mA
Mutual Conductance	g_m	1·72		mA/V
Anode Resistance ($\delta v_a/\delta i_a$)	r_a	11·6		kΩ
Amplification Factor	μ	20		

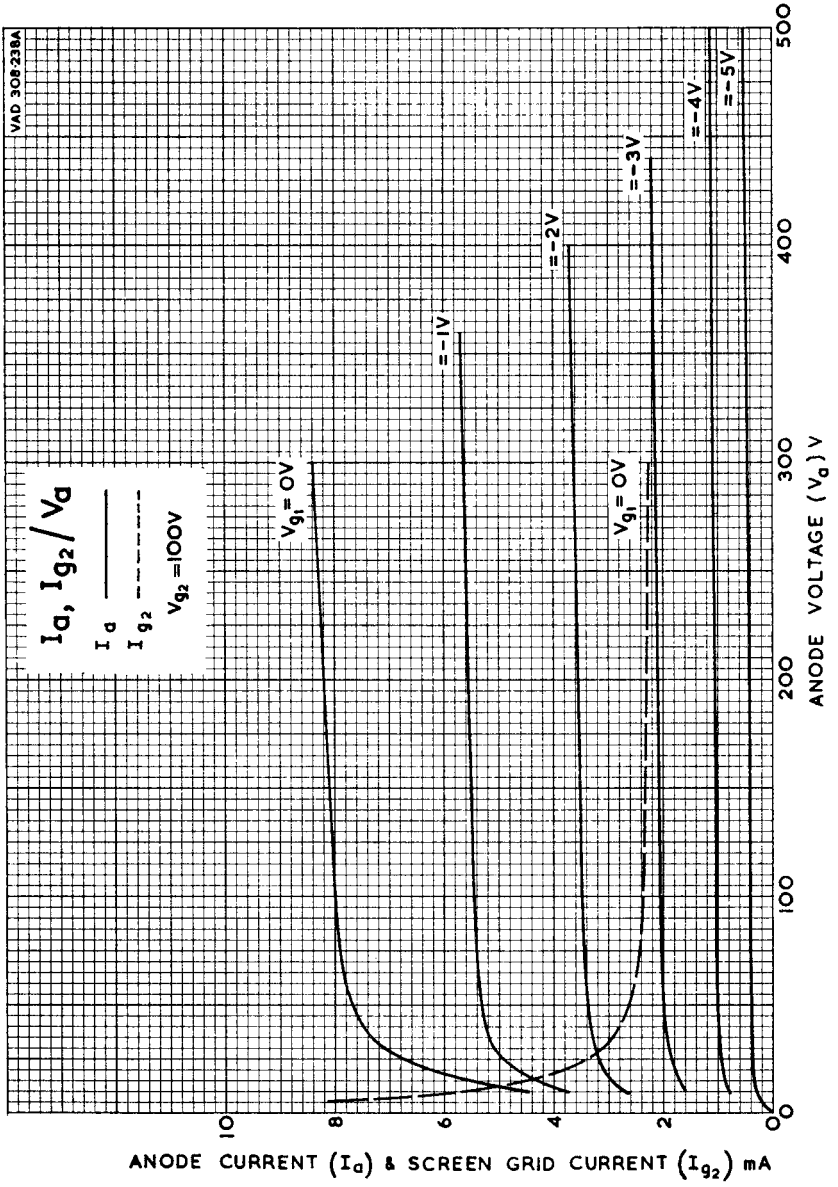
OPERATION AS A RESISTANCE CAPACITY COUPLED A.F. AMPLIFIER

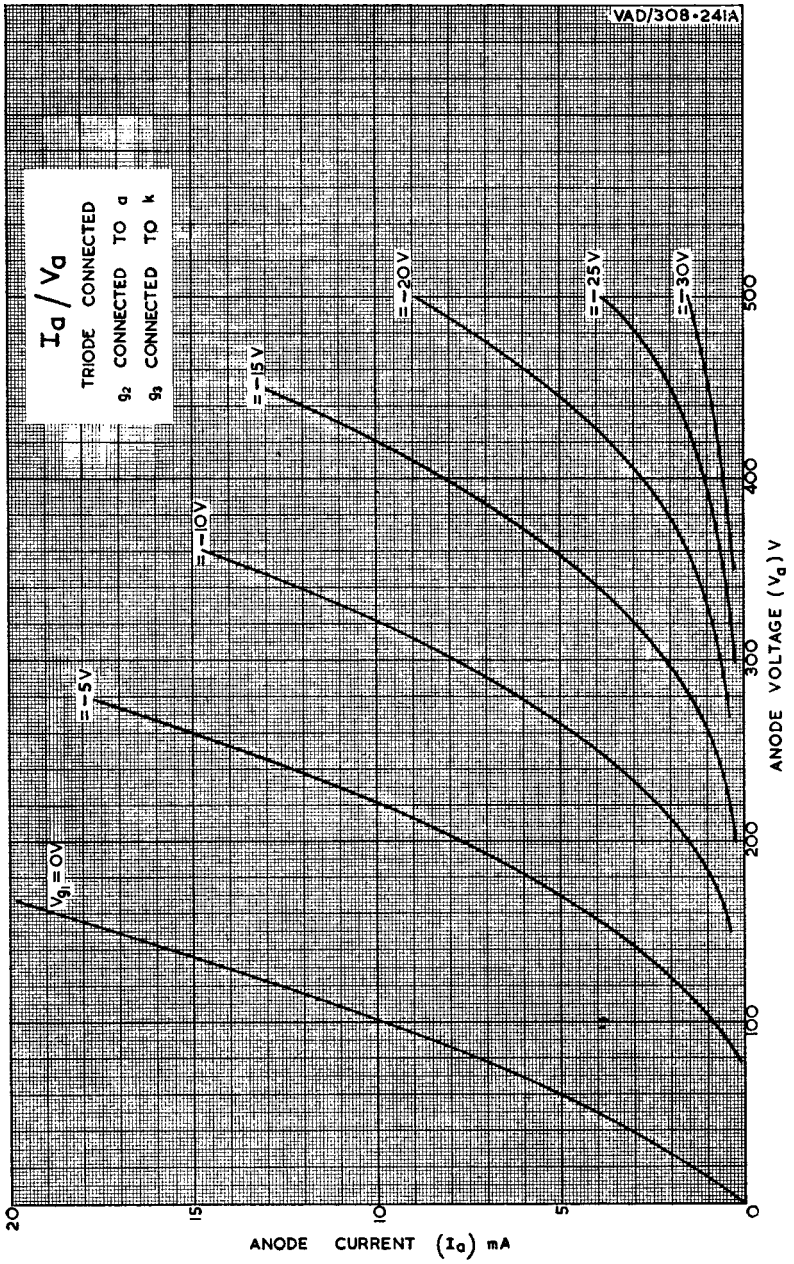
In the tables below are given typical operating conditions under various conditions of anode load and supply voltage which yield an output with approximately 5 per cent distortion.

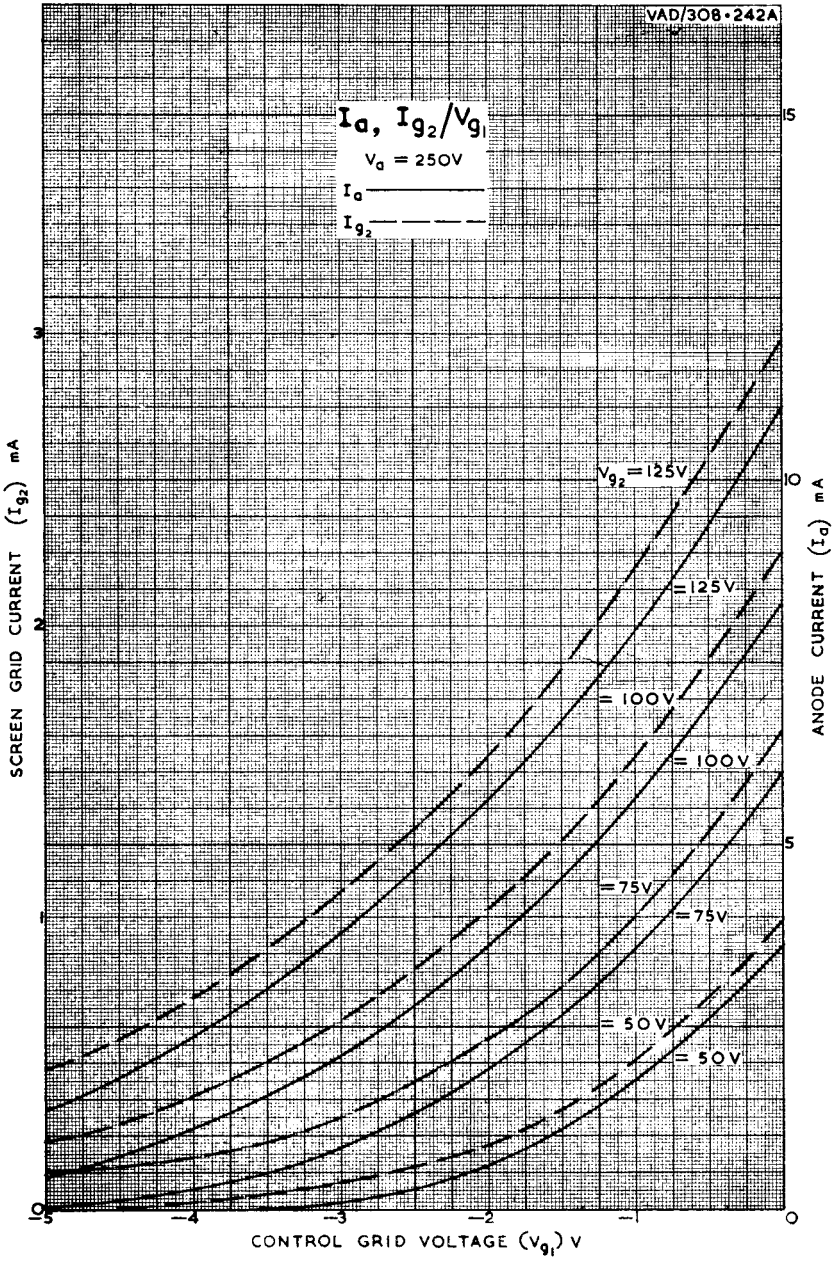
This valve may be used as a low μ triode resistance capacity coupled amplifier where the requirements for low hum and noise outweigh these for high gain.

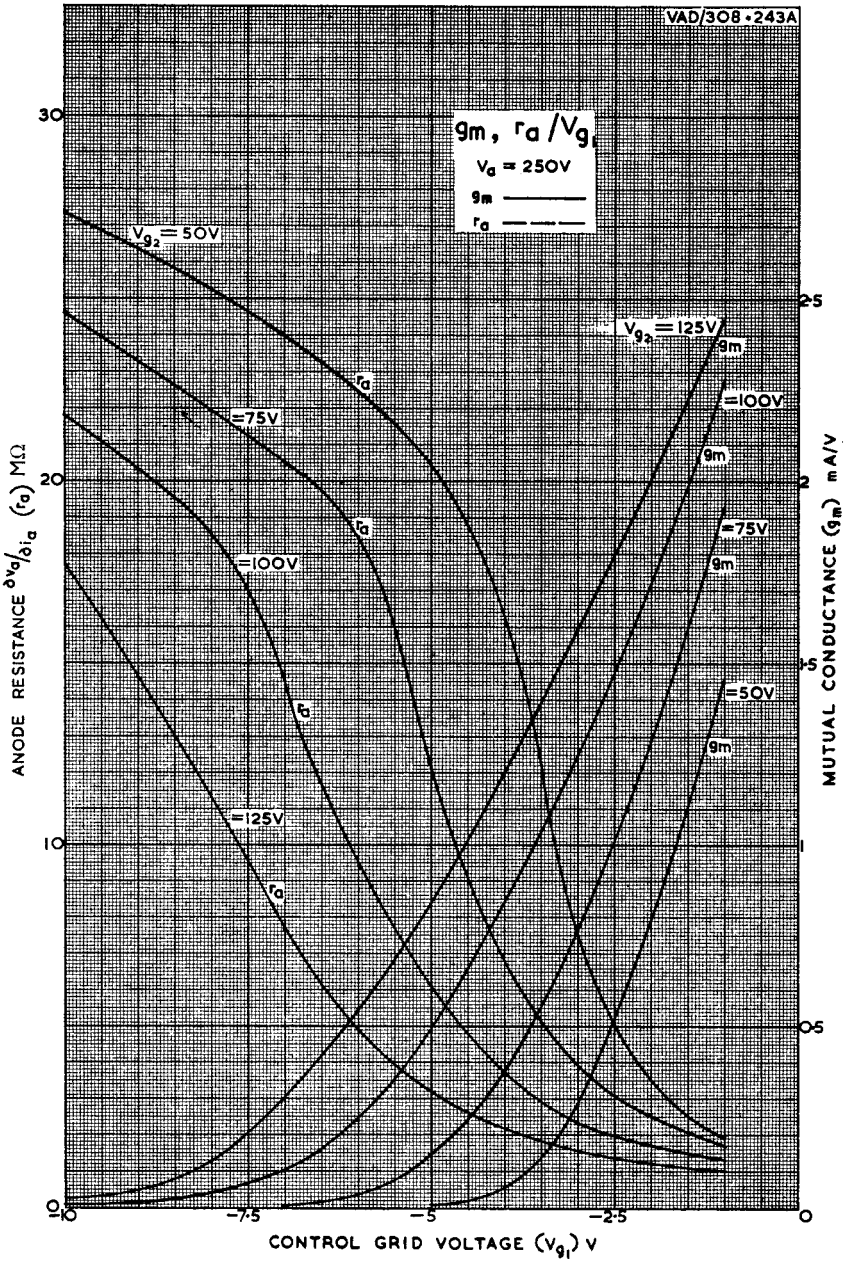
PENTODE CONNECTED								
Anode Supply Voltage	$V_{a(b)}$	100	100	100	300	300	300	V
Anode Load Resistor	R_a	100	220	470	100	220	470	kΩ
Cathode Bias Resistor	R_k	1·3	3·3	5·6	0·56	1·5	2·2	kΩ
Screen Grid Series Resistor	R_{g2}	0·47	1·5	2·8	0·47	1·5	2·8	MΩ
Succeeding Stage Grid Resistor	R_g	1	1	1	1	1	1	MΩ
Peak Output Voltage	$v_{out(pk)}$	21	28	31	70	92	100	V
Voltage Gain		65	80	140	104	124	185	

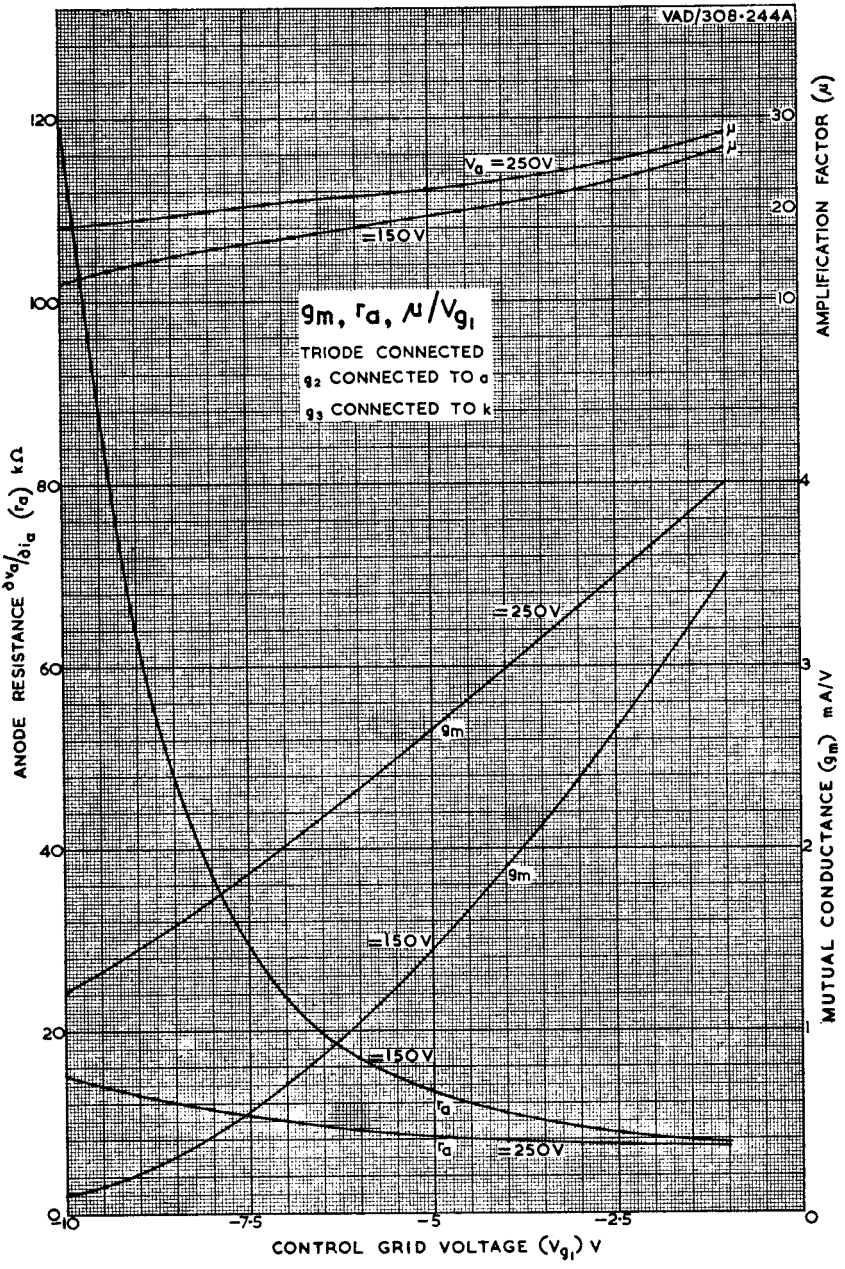
TRIODE CONNECTED								
Anode Voltage	$V_{a(b)}$	100	100	100	300	300	300	V
Anode Load Resistor	R_a	100	220	470	100	220	470	kΩ
Cathode Bias Resistor	R_k	7·5	14·5	20	6	14	18·6	kΩ
Succeeding Stage Grid Resistor	R_g	0·5	1	1	0·5	1	1	MΩ
Peak Output Voltage	$v_{out(pk)}$	22	26	28	88	96	105	V
Stage Gain		12	13	14	13	14	14	

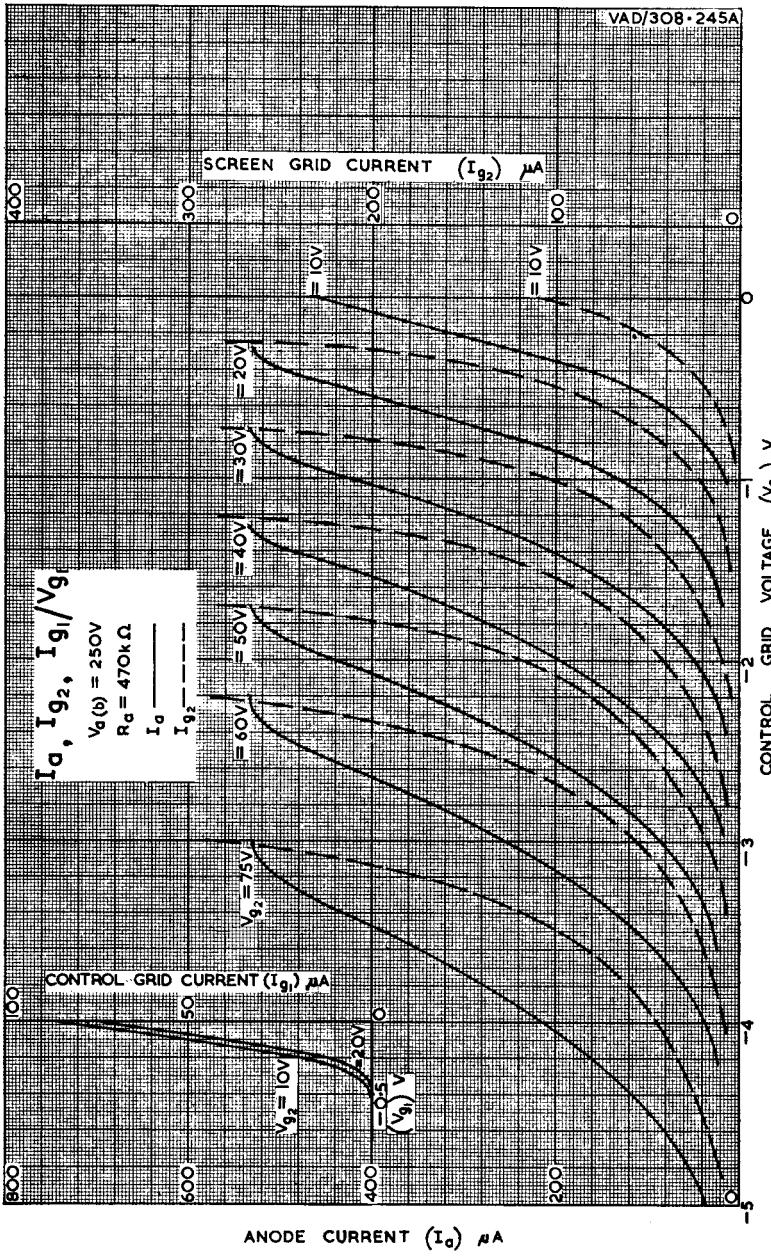

VAD 308-238A
$I_a, I_{g_2}/V_a$
I_a
I_{g_2}
V_{g_2} = 100V
V_{g_1} = 0V
= -1V
= -2V
= -3V
= -4V
= -5V
V_{g_1} = 0V
0
100
200
300
400
500
ANODE VOLTAGE (V_a) V
0
2
4
6
8
10
ANODE CURRENT (I_a) & SCREEN GRID CURRENT (I_{g_2}) mA

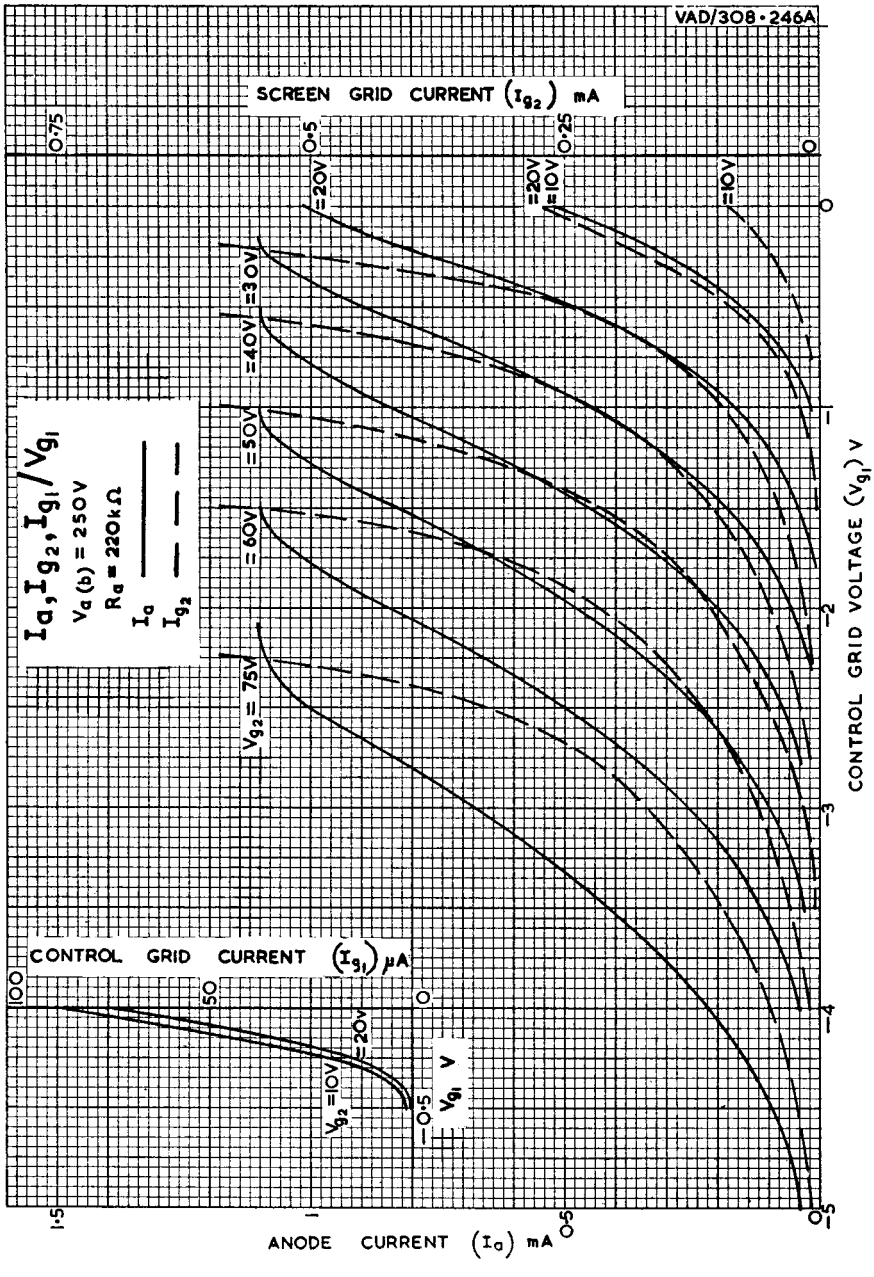

VAD/308-241A
I_a / V_a
TRIODE CONNECTED
g_2 CONNECTED TO a
g_3 CONNECTED TO k
V_{g1} = 0V
= −5V
= −10V
= −15V
= −20V
= −25V
= −30V
ANODE CURRENT (I_a) mA
ANODE VOLTAGE (V_a) V
0
5
10
15
20
100
200
300
400
500

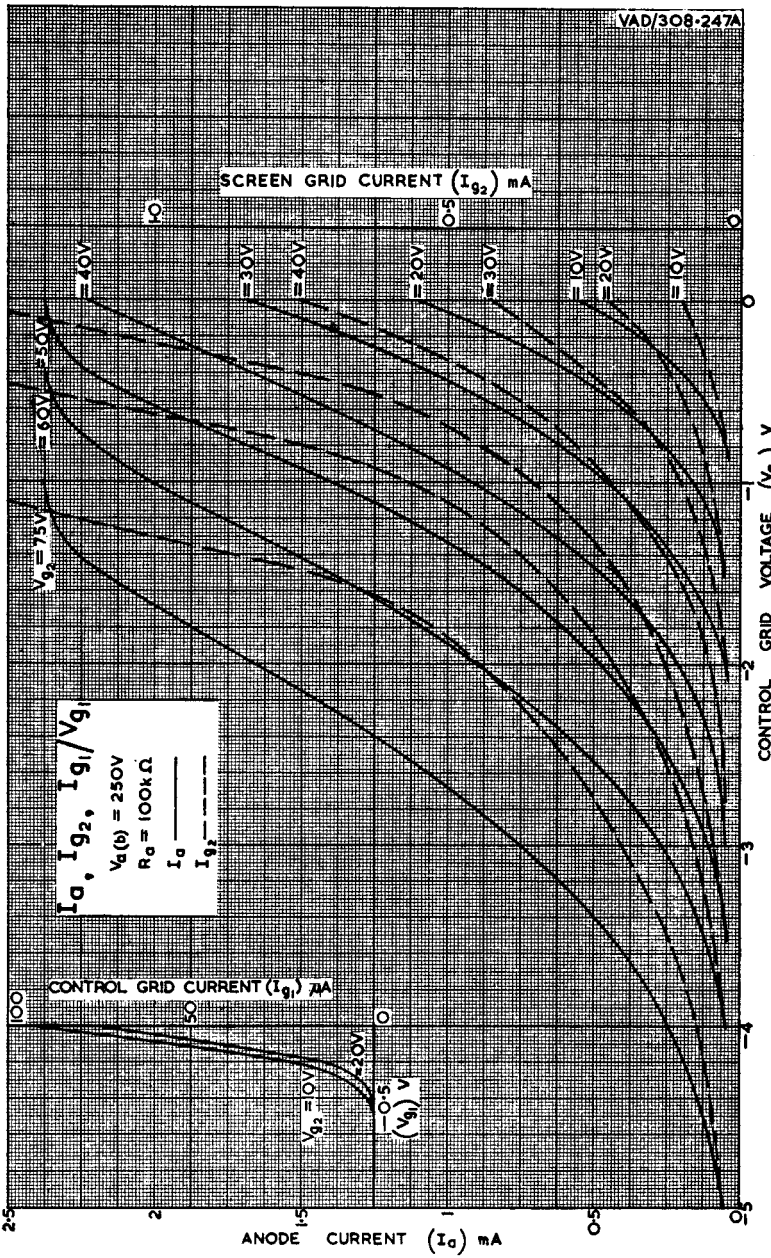

VAD/308·242A
$I_a, I_{g_2}/V_{g_1}$
V_a = 250V
I_a
I_{g_2}
V_{g_2} = 125V
= 125V
= 100V
= 100V
= 75V
= 75V
= 50V
= 50V
SCREEN GRID CURRENT (I_{g_2}) mA
ANODE CURRENT (I_a) mA
CONTROL GRID VOLTAGE (V_{g_1}) V
0
1
2
3
5
10
15
−5
−4
−3
−2
−1
0

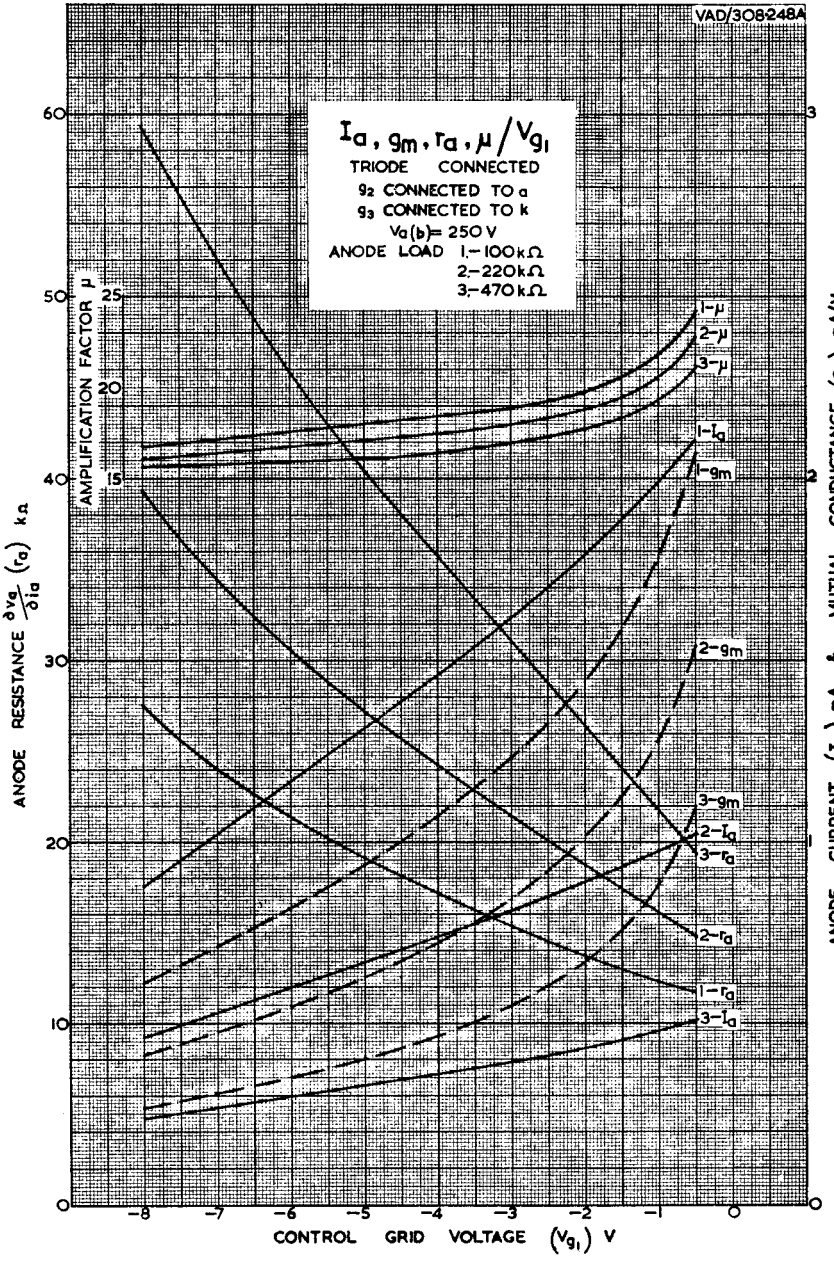

VAD/308•243A
gm, ra /Vg1
Va = 250V
gm
ra
Vg2 = 50V
=75V
=100V
=125V
Vg2 = 125V
=100V
=75V
=50V
ra
gm
ANODE RESISTANCE δVa/δIa (ra) MΩ
MUTUAL CONDUCTANCE (gm) mA/V
CONTROL GRID VOLTAGE (Vg1) V
30
20
10
0
2·5
2
1·5
1
0·5
0
-10
-7·5
-5
-2·5
0

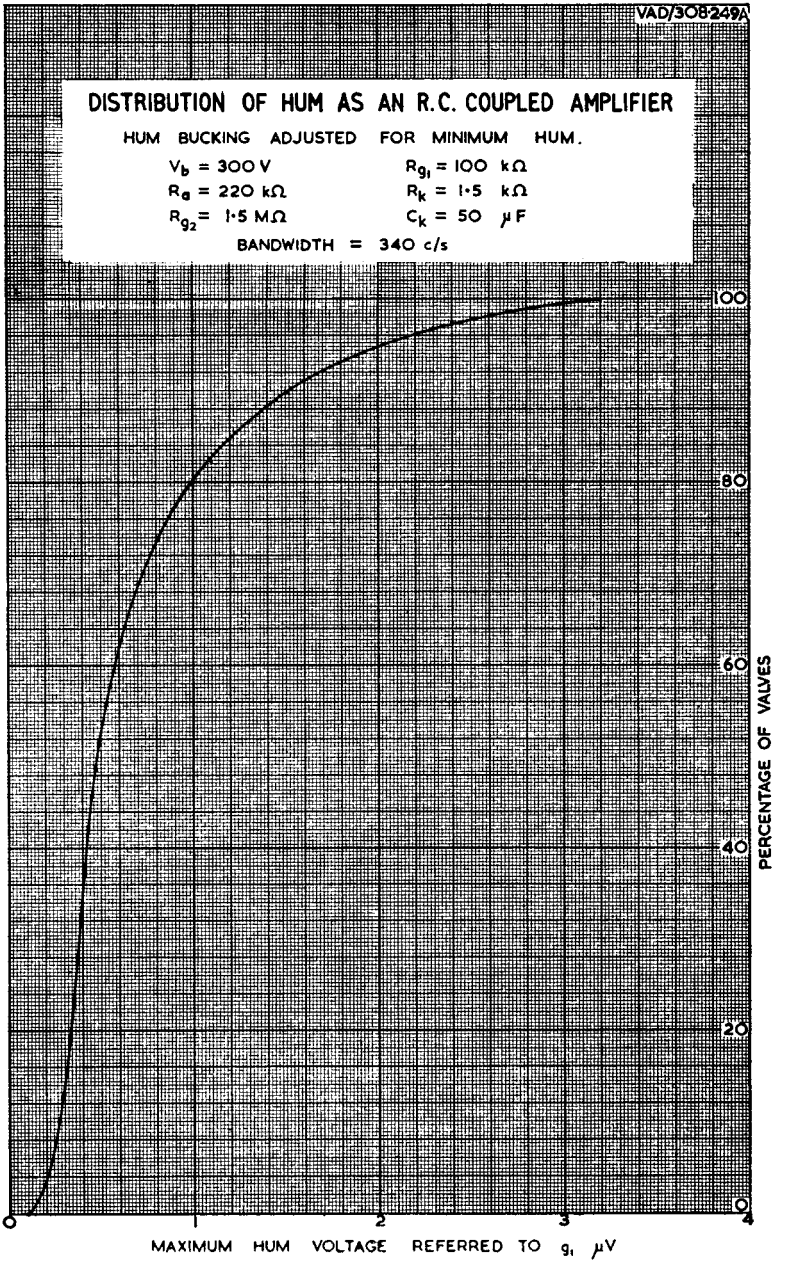

VAD/308-244A
g_m, r_a, μ/V_{g_1}
TRIODE CONNECTED
g_2 CONNECTED TO a
g_3 CONNECTED TO k
V_a =250V
=150V
μ
μ_2
g_m
r_a
ANODE RESISTANCE $\partial v_a/\partial i_a$ (r_a) kΩ
AMPLIFICATION FACTOR (μ)
MUTUAL CONDUCTANCE (g_m) mA/V
CONTROL GRID VOLTAGE (V_{g_1}) V
120
100
80
60
40
20
0
30
20
10
4
3
2
1
0
-10
-7·5
-5
-2·5


VAD/308-245A
SCREEN GRID CURRENT (I_{g_2}) μA
400
300
200
100
0
I_a, I_{g_2}, I_{g_1}/V_{g_1}
$V_{a(b)}$ = 250V
R_a = 470kΩ
I_a ——
I_{g_2} – – –
= 10V
= 20V
= 30V
= 40V
= 50V
= 60V
V_{g_2} = 75V
CONTROL GRID CURRENT (I_{g_1}) μA
100
50
0
V_{g_2} = 10V
-20V
-0.5
(V_{g_1}) V
800
600
400
200
0
0
-1
-2
-3
-4
-5
CONTROL GRID VOLTAGE (V_{g_1}) V
ANODE CURRENT (I_a) μA


VAD/308·246A
SCREEN GRID CURRENT (I_{g_2}) mA
0·75
0·5
0·25
0
=20V
=10V
=40V
=30V
=50V
=60V
V_{g_2} = 75V
$I_a, I_{g_2}, I_{g_1}/V_{g_1}$
V_a (b) = 250 V
R_a = 220kΩ
I_a
I_{g_2}
CONTROL GRID VOLTAGE (V_{g_1}) V
0
−1
−2
−3
−4
−5
CONTROL GRID CURRENT (I_{g_1}) μA
100
50
0
=20V
=10V
V_{g_2}
−0·5
V
V_{g_1}
1·5
1
0·5
0
ANODE CURRENT (I_a) mA


VAD/308-247A
SCREEN GRID CURRENT (I_{g_2}) mA
I_a, I_{g_2}, I_{g_1}/V_{g_1}
V_a(b) = 250V
R_a = 100kΩ
I_a
I_{g_2}
CONTROL GRID CURRENT (I_{g_1}) μA
ANODE CURRENT (I_a) mA
CONTROL GRID VOLTAGE (V_{g_1}) V
V_{g_2} = 75V
V_{g_2} = 60V
V_{g_2} = 50V
V_{g_2} = 40V
V_{g_2} = 30V
V_{g_2} = 20V
V_{g_2} = 10V
V_{g_2} = 0V
-20V
-10V
0
-0·5
-1
-1·5
-2
-3
-4
2·5
2
1·5
1
0·5
0
100
50
0
0·5
1·0


VAD/308248A
$I_a, g_m, r_a, \mu / V_{g_1}$
TRIODE CONNECTED
g_2 CONNECTED TO a
g_3 CONNECTED TO k
$V_{a(b)}$= 250 V
ANODE LOAD 1.–100kΩ
2.–220kΩ
3.–470kΩ
1–μ
2–μ
3–μ
1–I_a
1–g_m
2–g_m
3–g_m
2–I_a
3–r_a
2–r_a
1–r_a
3–I_a
AMPLIFICATION FACTOR μ
ANODE RESISTANCE $\frac{\partial V_a}{\partial I_a}$ (r_a) kΩ
MUTUAL CONDUCTANCE (g_a) mA/V
ANODE CURRENT (I_a) mA
CONTROL GRID VOLTAGE (V_{g_1}) V
60
50
40
30
20
10
0
25
20
15
3
2
1
0
−8
−7
−6
−5
−4
−3
−2
−1
0


VAD/308249A
DISTRIBUTION OF HUM AS AN R.C. COUPLED AMPLIFIER
HUM BUCKING ADJUSTED FOR MINIMUM HUM.
V_b = 300 V
R_a = 220 kΩ
R_{g_2} = 1·5 MΩ
R_{g_1} = 100 kΩ
R_k = 1·5 kΩ
C_k = 50 μF
BANDWIDTH = 340 c/s
100
80
60
40
20
0
PERCENTAGE OF VALVES
0
1
2
3
4
MAXIMUM HUM VOLTAGE REFERRED TO g_1 μV

ELECTROMETER APPLICATIONS

The 6BS7, because of its specialised construction, may be operated with grid currents of less than 5pA (i.e. 5×10^{-12}A). To obtain this very low figure a special circuit and special precautions are necessary.

It should be noted that a proportion only of 6BS7 valves have grid currents of less than 5pA; the rest exceed this value and are unsuitable for electrometer applications. These grid current levels quoted are for a cathode current of 5μA. In the recommended region of operation, which is about $-2{\cdot}5$ to -3V, the grid current is approximately proportional to cathode current. Lower grid currents and increased gain may be obtained near the "crossover" point, normally about -1V bias, where the grid current changes from negative to positive. This point may change with ageing and cause a relatively large increase of grid current as the grid current, grid voltage characteristic is very steep at this point.

If electrometer use is intended, this should be stated at the time of ordering.

SPECIAL PRECAUTIONS

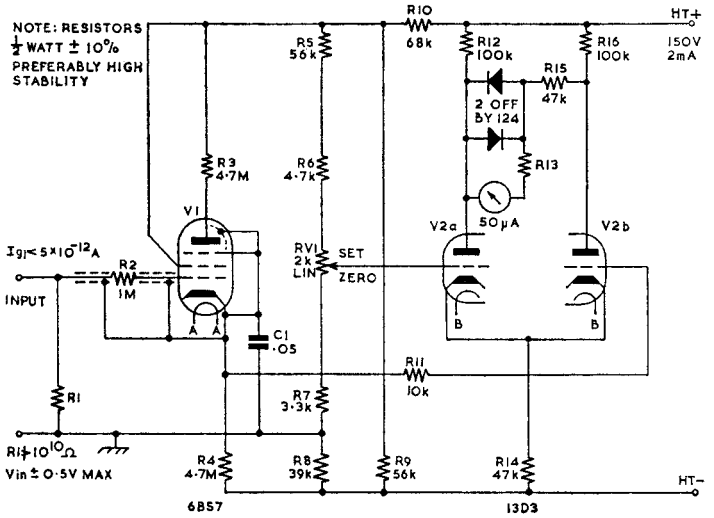
To obtain the lowest possible grid currents and minimum drift the following precautions should be observed.

1. A stabilised H.T. voltage should be used and applied not less than one minute after the heater voltage.
2. The heater voltage of the 6BS7 should be stabilised to within $\pm 0{\cdot}05$ per cent.
3. The voltage developed across R_1 should not exceed 0·5V. (See Fig. 1.)
4. The valves must be operated in total darkness.
5. The bulbs must be perfectly clean.
6. The instrument should be screened from stray electrostatic fields.
7. At least one hour must be allowed for the valves to stabilise for short term measurements. At least 200 hours must be allowed for long term measurements.

CIRCUIT AND TYPICAL OPERATION

A suitable electrometer circuit using the 6BS7 and an associated D.C. amplifier is shown in figure 1. The power supplies may be obtained using the circuit shown in figure 2. Results using these circuits are as follows:

	Short Term Measurements	Long Term Measurements	
6BS7 heater voltage	5·0	5·0	V
Stabilisation period	1·0	200	h
Resistance R_1	5×10^9	5×10^9	Ω
Input current	25	25	pA
Output current	12	12	μA
Typical output meter zero drift			
(*a*) Five minute period	0·05	0·05	μA
(*b*) Twenty-four hour period	—	1·2	μA



RI3 CHOSEN TO GIVE ADEQUATE METER PROTECTION WITHOUT CRAMPING SCALE TYPICALLY 2·7kΩ WITH 120mV MOVEMENT

00 93A

FIG.1. ELECTROMETER CIRCUIT USING 6BS7 AND 13D3

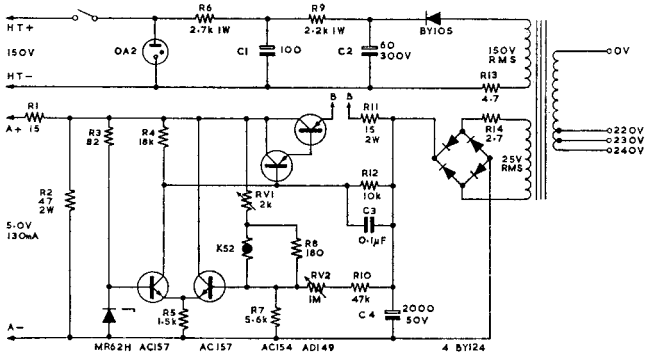


FIG. 2. POWER SUPPLY

0153A

Notes

1. RV1 set for 5·0 volts at output.
2. RV2 set to give minimum change of output voltage for ±10 per cent change in supply voltage.
3. Unless stated, all resistors ½ watt ± 10% preferably high stability.
4. Temperature compensation has been introduced by using a thermistor (e.g. STC type K52). In practice it may be necessary to match the characteristics of this thermistor and the zener diode to get optimum results.

Warning.

1. If the heater supply is operated whilst the 6BS7 is disconnected the zener diode will exceed its rating.
2. Connections BB must be made to pins 4 and 5 on the 13D3 base.