G.E.C. Advance Technical Information

CV4520

ISSUE 2

MAY 1963

LOW IMPEDANCE TRIODE
6.3V INDIRECTLY HEATED

The CV4520 is an indirectly heated triode designed for use as a low impedance stabiliser valve in environments of extreme shock and vibration.

BASE CONNECTIONS AND VALVE DIMENSIONS

1.	a	5.	h
2.	k	6.	g
3.	a	7.	IC
4.	h	8.	a
		9.	a

Base :	B9A/F
Bulb :	Tubular
Max. seated length :	66mm
Max. diameter :	22.2mm
Min. lead length :	38mm

HEATER

V_h	6.3 ±5%	V
$*I_h$	1.1 ±0.1	A

*This test is performed on an agreed sample basis.

MAXIMUM RATINGS (Absolute)

$V_{a(b)}$	500	V
V_a	300	V
$-V_g$	100	V
p_a	15	W
I_k	125	mA
R_{g-k} (fixed bias)	100	kΩ
R_{g-k} (cathode bias)	500	kΩ
$*V_{h-k}$ (cathode positive)	250	V
$*V_{h-k}$ (cathode negative)	100	V
T_{bulb}	225	°C
Acceleration (continuous operation)		
†100 hours duration :	5.0	g
† 10 mins. duration :	20.0	g
Shock (short duration) :	500	g
Operating pressure (min) :	55	mm of Hg
Ambient storage temperature range :	-60 to +85	°C

*For maximum reliability V_{h-k} should not exceed 10V.

†When the vibration components are varying continuously over the spectrum 10 to 1000c/s in a random manner.

CAPACITANCES (Measured on a cold screened valve *)

†$c_{g\text{-all less a}}$:	7.1pF ±1.4pF	†$c_{a\text{-all less g}}$:	6.0pF ±1.2pF
†$c_{g\text{-}a}$:	9.5pF ±1.75pF		

*Measured at 1Mc/s in an approved manner.

†These tests are performed on an agreed sample basis.

CHARACTERISTICS

(i)	V_a	150	100	V
	I_a	100	2.0	mA
	$-V_g$	21.5 ±4.5†	35 (max)‡	V
	*g_m	11.0 ±2.0‡	-	mA/V
	I_g (R_{g-k} = 500kΩ)	2.0 (max)†	-	µA
	µ	4.5 ±1.0‡	-	-
	*§Δg_m	8.0 (max)‡	-	%

(ii)	V_a	170	V
	R_k (R_{g-k} = 0)	170	Ω
	I_a	100	mA
	″t_{hk}	40 (max)‡	s

(iii)	V_a	200	200	V
	R_a	1.0	1.0	kΩ
	R_k (c_k ≥1000µF)	200	200	Ω
	f	50	1000 to 2500	c/s
	Acceleration(pk)	20 (min)	5.0 (min)	g
	$V_{out(rms)}$	120 (max)†	350 (max)†	mV

(iv)	V_h	6.3	6.3	6.3	V
	$V_{a\text{-all}}$	-300	-	-	V
	$V_{g\text{-all}}$	-	-100	-	V
	V_{h-k}	-	-	±250	V
	R (insulation)	100 (min)†	100 (min)†	-	MΩ
	I_{h-k}	-	-	20 (max)‡	µA

(v)	V_h	6.3	Running conditions for 1000 hours life test‡	V
	V_a	120		V
	I_a	125		mA
	$V_{h-k(rms)}$ (50c/s)	200		V

Cont'd.....

CHARACTERISTICS (Continued)

After 1000 hours operation:-

V_a	150	V
I_a	100	mA
$-V_g$	15.5 (min)‡	V
$-V_g$	26.0 (max)‡	V
I_g ($R_{g-k} = 500k\Omega$)	3.0 (max)‡	µA
V_{h-k}	±250	V
I_{h-k}	30 (max)‡	µA

*Measured in an approved manner.

†Every valve tested.

‡These tests are performed on an agreed sample basis.

§Δg_m is defined here as:-

$$\Delta g_m = \frac{(g_m \text{ at } V_h = 6.3V) - (g_m \text{ at } V_h = 5.7V)}{(g_m \text{ at } V_h = 6.3V)} \times 100\%$$

‖t_{hk} is defined here as the time taken for I_a to rise to 100mA, from switching on the heater of a valve whose heater has not been operated for at least two hours. The impedance of the heater voltage supply must be low enough to ensure that $V_h = 6.3V$ throughout the heating time.

INSTALLATION

The valve may be mounted in any position.

TESTING

These valves are manufactured in discrete lots, under carefully controlled conditions. Each lot is very comprehensively tested for electrical and mechanical properties in a manner specified by the relevant Government Authority.

The limits imposed in the electrical tests are usually closer than those used in normal domestic or commercial valve testing and include control on the spread of characteristic parameters.

Random samples are also taken from each lot and subjected to specified destructive electrical and mechanical life test.

The lot is only released if it passes all the above tests, including the life test.

The careful control of manufacture and the comprehensive testing and lot release system are designed to reduce microphony, the spread in electrical properties, the incidence of early failures and provide known life performance within the specified electrical and mechanical maximum ratings. An article in British Communications and Electronics (April 1958) by R. Brewer of the G.E.C. Research Laboratories entitled "The Life Test Contribution to the Improvement of Valve Reliability" discusses these points more fully. Reprints can be supplied on request.

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APPLICATIONS DATA

FOR

VALVE TYPE

CV4520

This information is intended for the guidance of users and does not form part of the procurement specification

ISSUE I SEPTEMBER 1961

ISSUED BY:-
MINISTRY OF AVIATION T.L.5. (B)
CASTLEWOOD HOUSE.
77-91 NEW OXFORD STREET.
LONDON. W.C.1.

AMENDMENTS

No:	Date	Page

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STATISTICAL ASPECTS OF CV4500 SPECIFICATIONS

These test specifications have been drawn up on a statistical basis involving the following considerations:-

1. The use of 100% testing on its own does not, with presently known methods, and with reasonable economy, result in 100% perfect items reaching the customer, because reliability cannot be tested into a product.

2. To control the average and spread of the characteristics of a batch of valves is a better guarantee that the product is under control, than to accept all of a product solely on the basis that the characteristics lie within certain limits. In general it is true to say that a valve which is just inside a limit is neither better nor more reliable than one which is just outside that limit.

3. It may be demonstrated that the main characteristics of valves fairly closely follow normal or log-normal Gaussian distributions.

The inspection of these valves when submitted for acceptance is therefore carried out in two complementary stages.

Acceptance Sampling by Attributes.

Each Attribute sampling test in the specification has two conditions which define the inspection which must be made in order to ensure that the corresponding characteristic meets the required standard. The conditions are:-

(a) The Inspection Level, which defines, directly or indirectly, the size of the sample which must be taken.

(b) The Acceptance Quality Level (AQL), which defines, indirectly, the number of rejects which can be tolerated in the sample.

These conditions also define the Operating Characteristic of the sampling scheme (Page 5), which gives the relationship between the quality of the submitted lot and the probability of its acceptance. In general the levels are so calculated that if lots containing a percentage of rejects equal to the AQL were constantly submitted, then approximately 95% of the lots would be accepted.

It can be seen that the above scheme only defines the permissible percentage of valves outside the specified test limits, and not the distribution of the values of the characteristic within those limits. Theoretically therefore, it would be possible for all the values to lie just within a limit and the product would still be accepted.

To ensure that this situation does not occur on the major electrical characteristics, Variables sampling is introduced.

Acceptance Sampling by Variables

Each Variables sampling test in the specification has one condition which defines the inspection which must be made in order to ensure that the corresponding characteristic meets the required standard. This condition is the Inspection Level, which defines the size of the sample which must be taken.

The sample is divided into groups of five and the required characteristics are recorded. From these results the average value of each characteristic for the whole sample, and the average of the individual ranges for each group of five, are calculated. These values define the location and the dispersion of the characteristic distribution, respectively. The average must lie between the Lower Acceptance Limit (LAL) and the Upper Acceptance Limit (UAL), and the average range must not exceed the Acceptance Limit for Dispersion (ALD)

/Illustrations

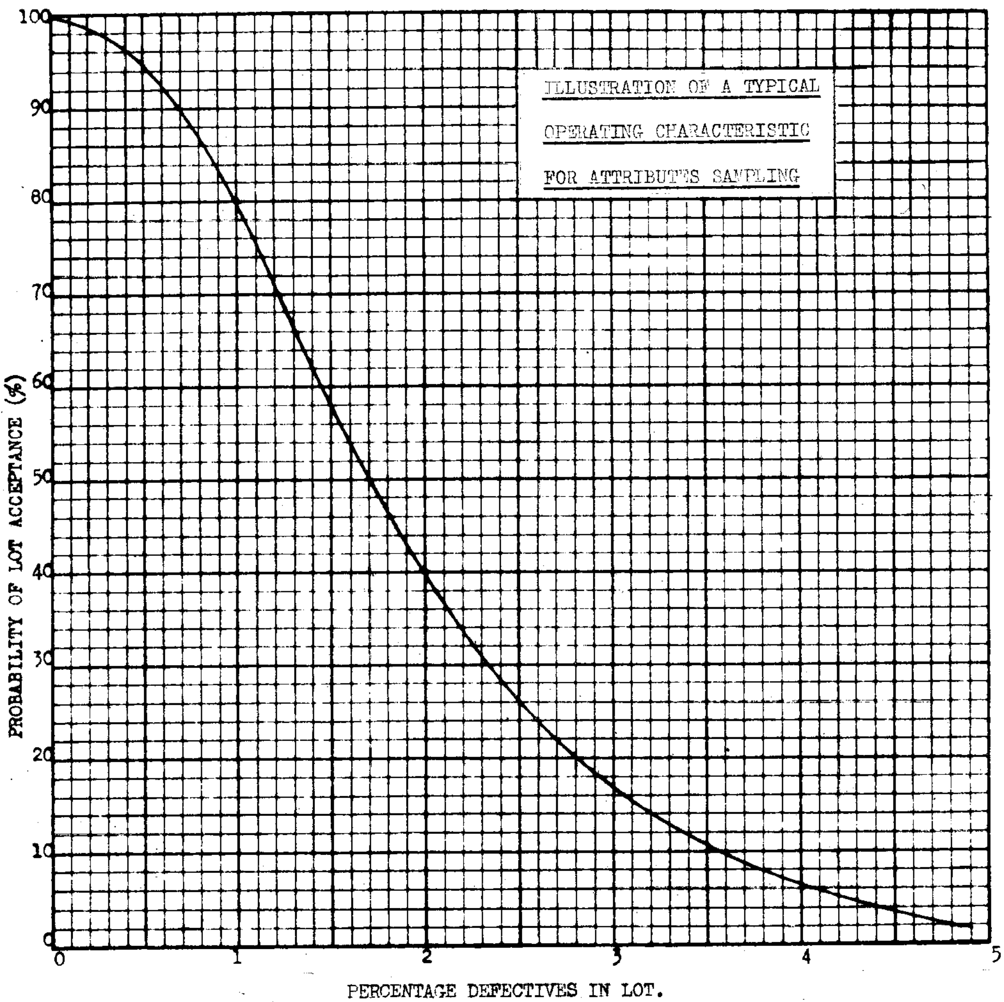
Illustrations of the limiting distributions for this valve, which would be just accepted by the above controls, are given on Pages 6 and 7. These show normal curves with the maximum permissible spread allowed by the ALD, centered on the LAL and UAL, respectively, and the maximum spread distributions, centered on the bogey value.

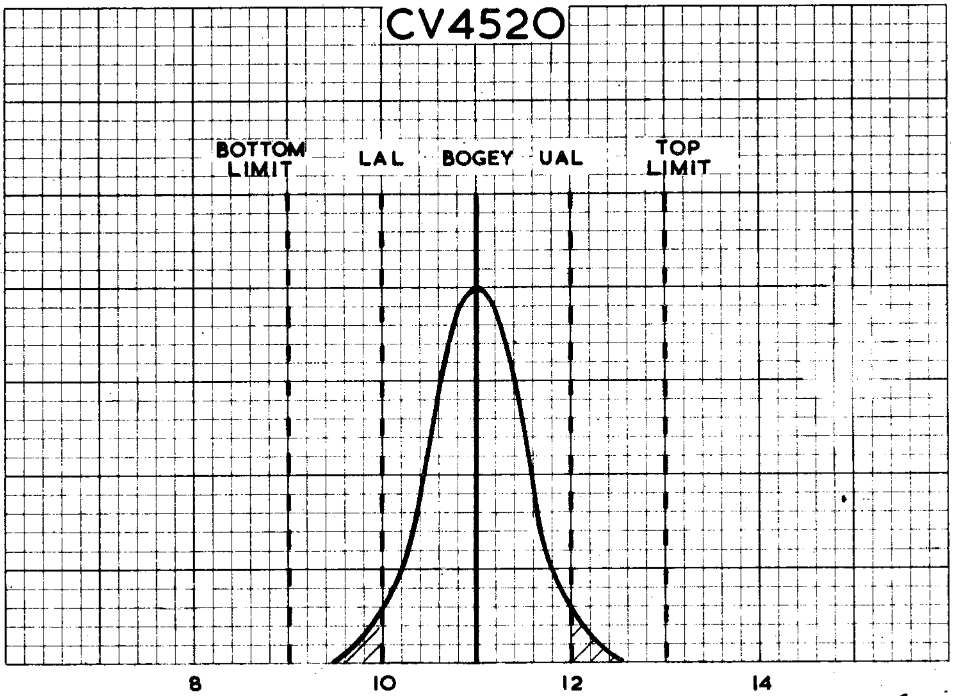
For further details of sampling inspection procedures for Attributes and Variables, reference should be made to K1001, Appendix XI, and MIL Standard 105A, Sampling Procedures and Tables for Inspection by Attributes.

Typical Operating Characteristic

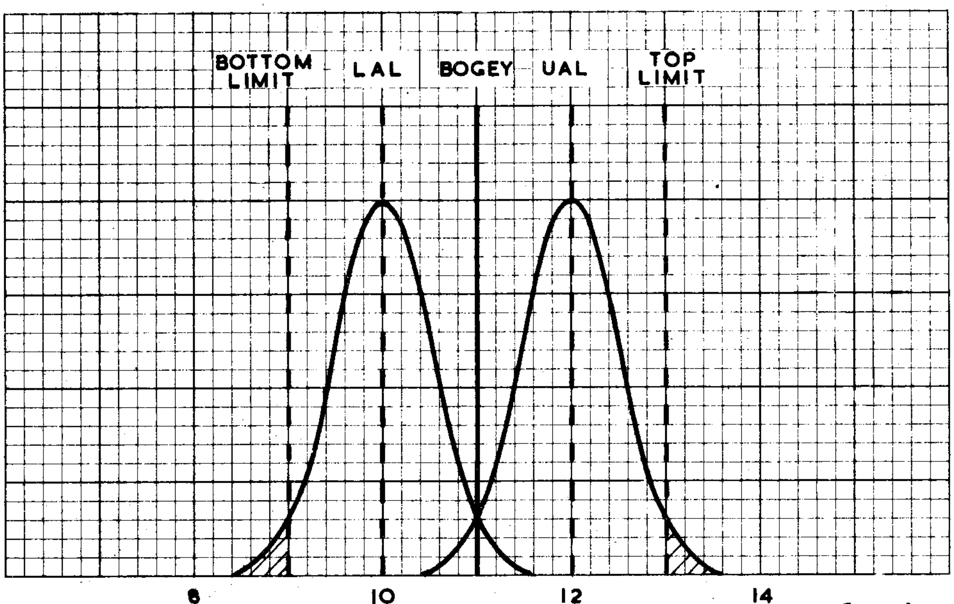
The following curve gives a typical Operating Characteristic for:-

Lot Size of between 1301 and 3200
Inspection Level II (Code Letter L, Sample size 150)
An AQL of 0.4% (Accept on 2, reject on 3).

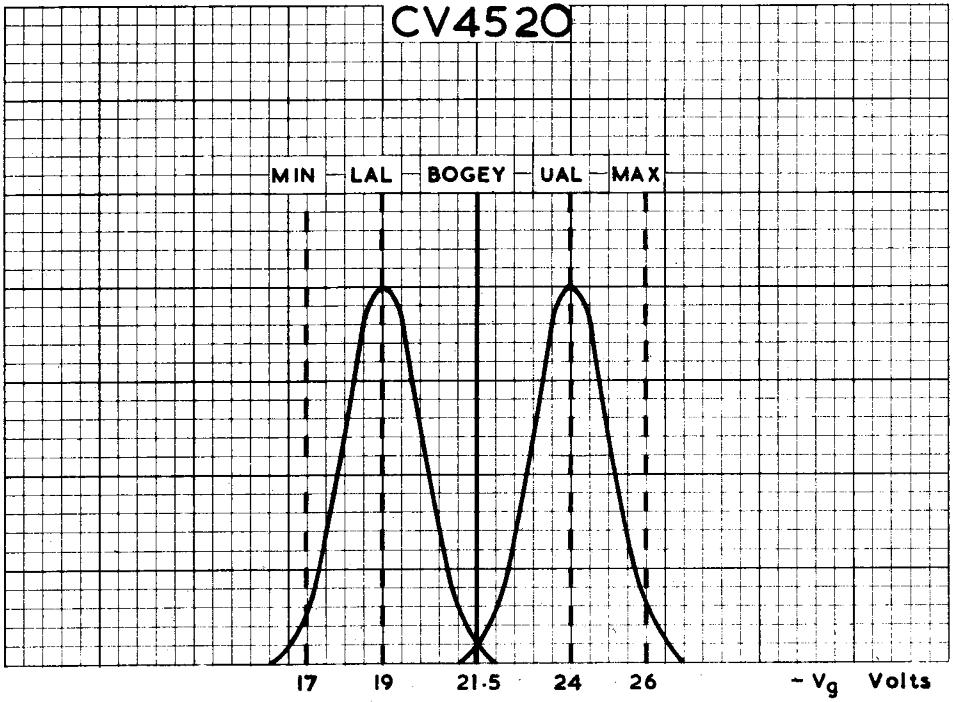




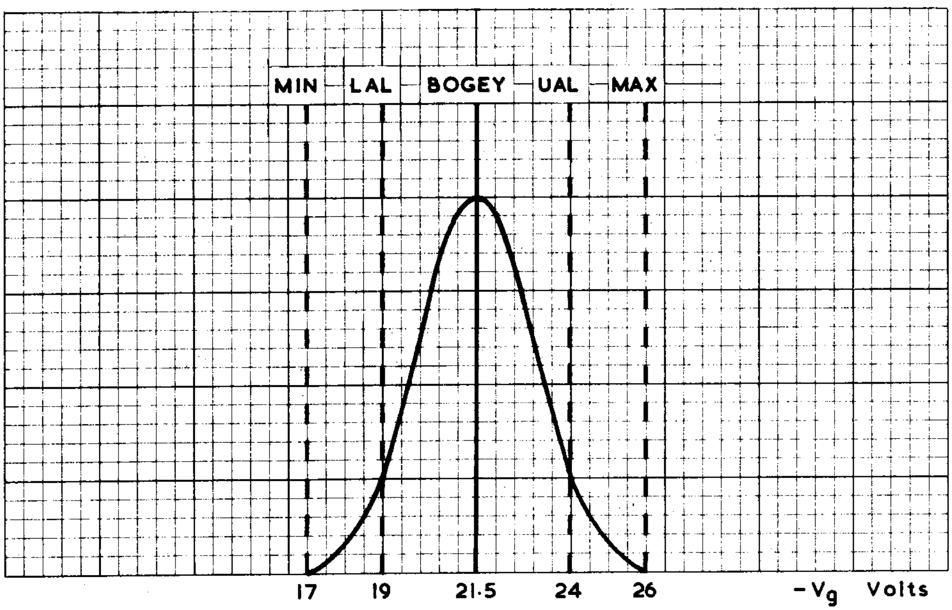
NORMAL GUASSIAN DISTRIBUTION OF MUTUAL CONDUCTANCE (mA/v)



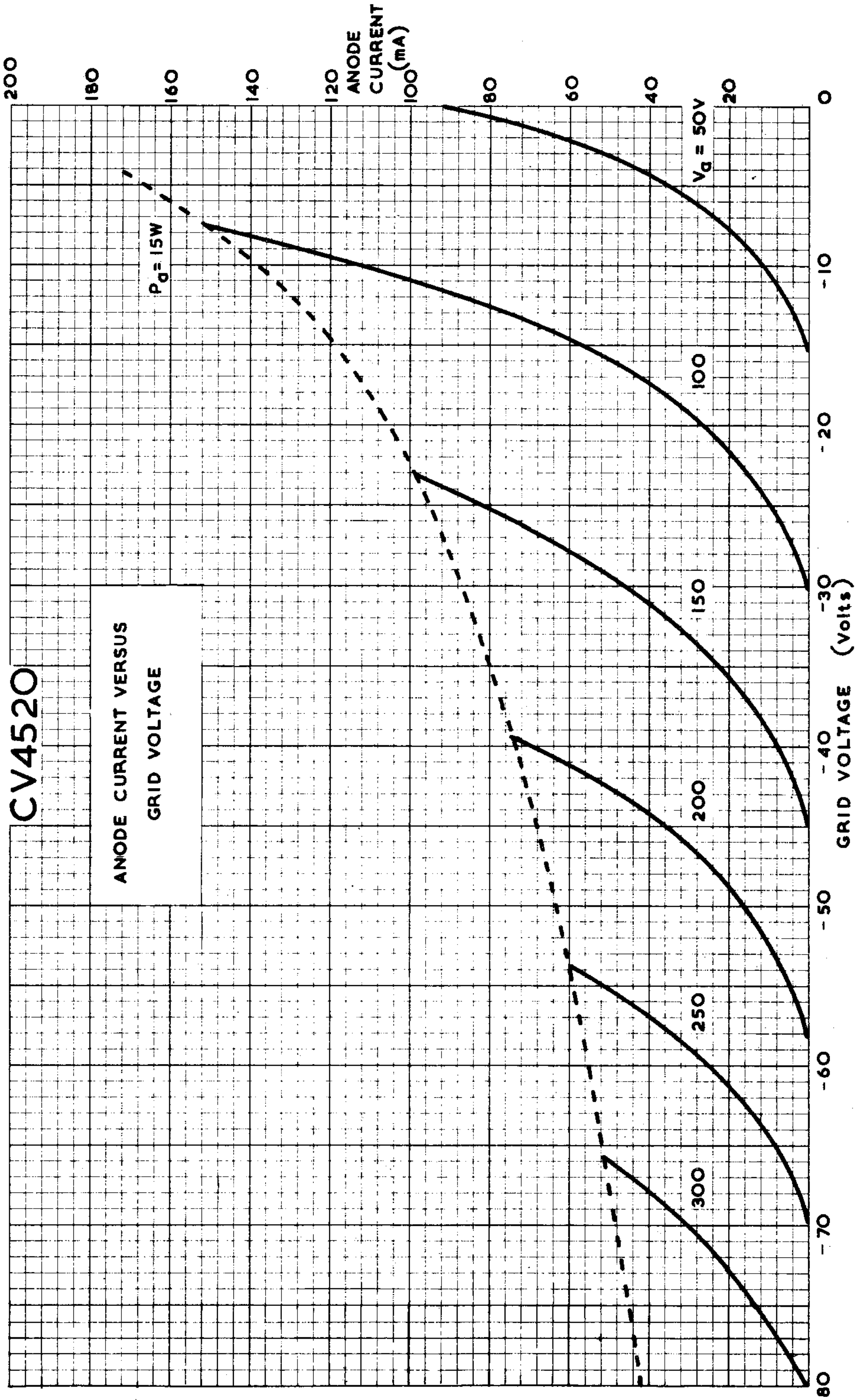
LIMITING DISTRIBUTIONS OF MUTUAL CONDUCTANCE (mA/v)

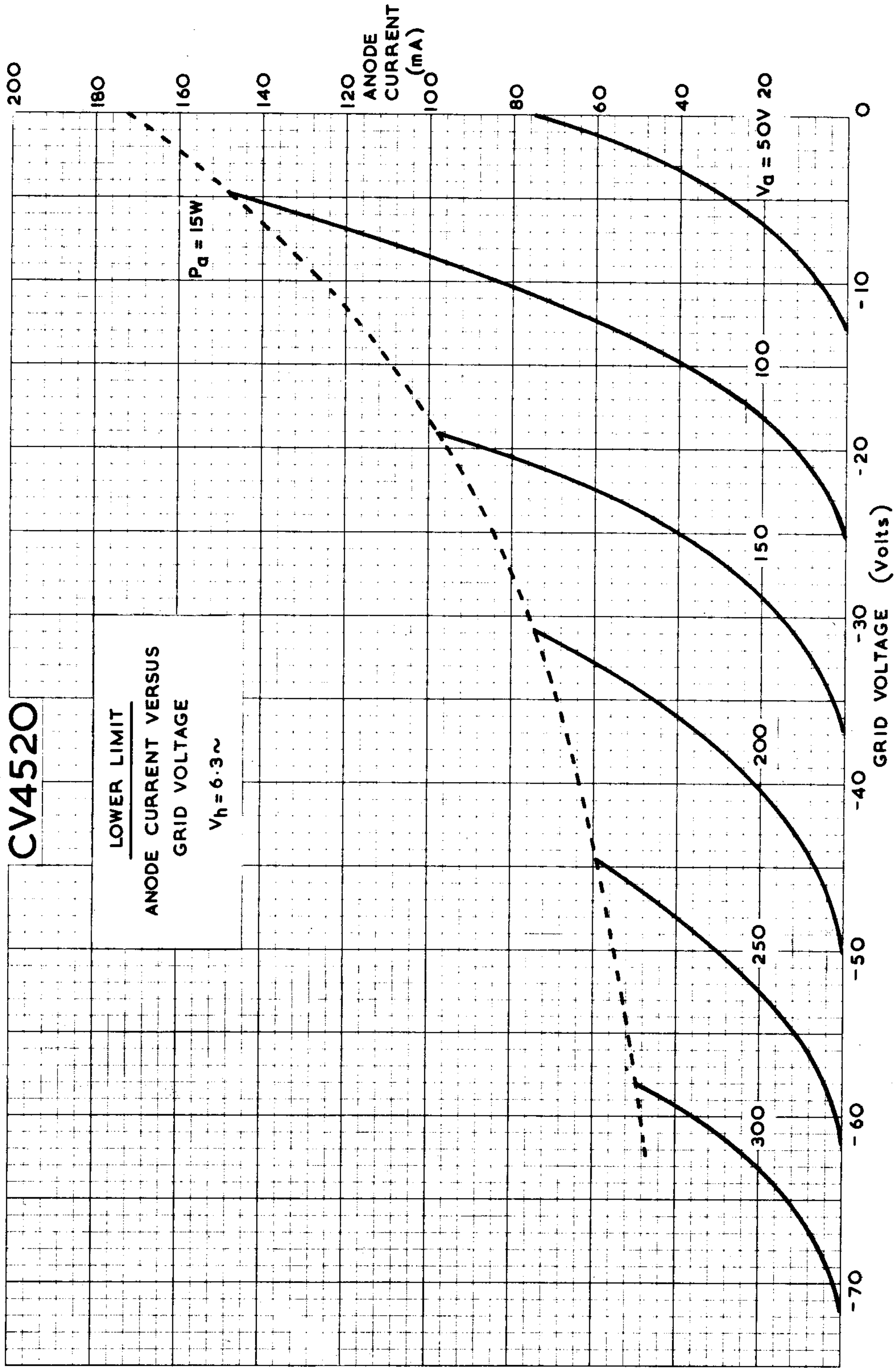


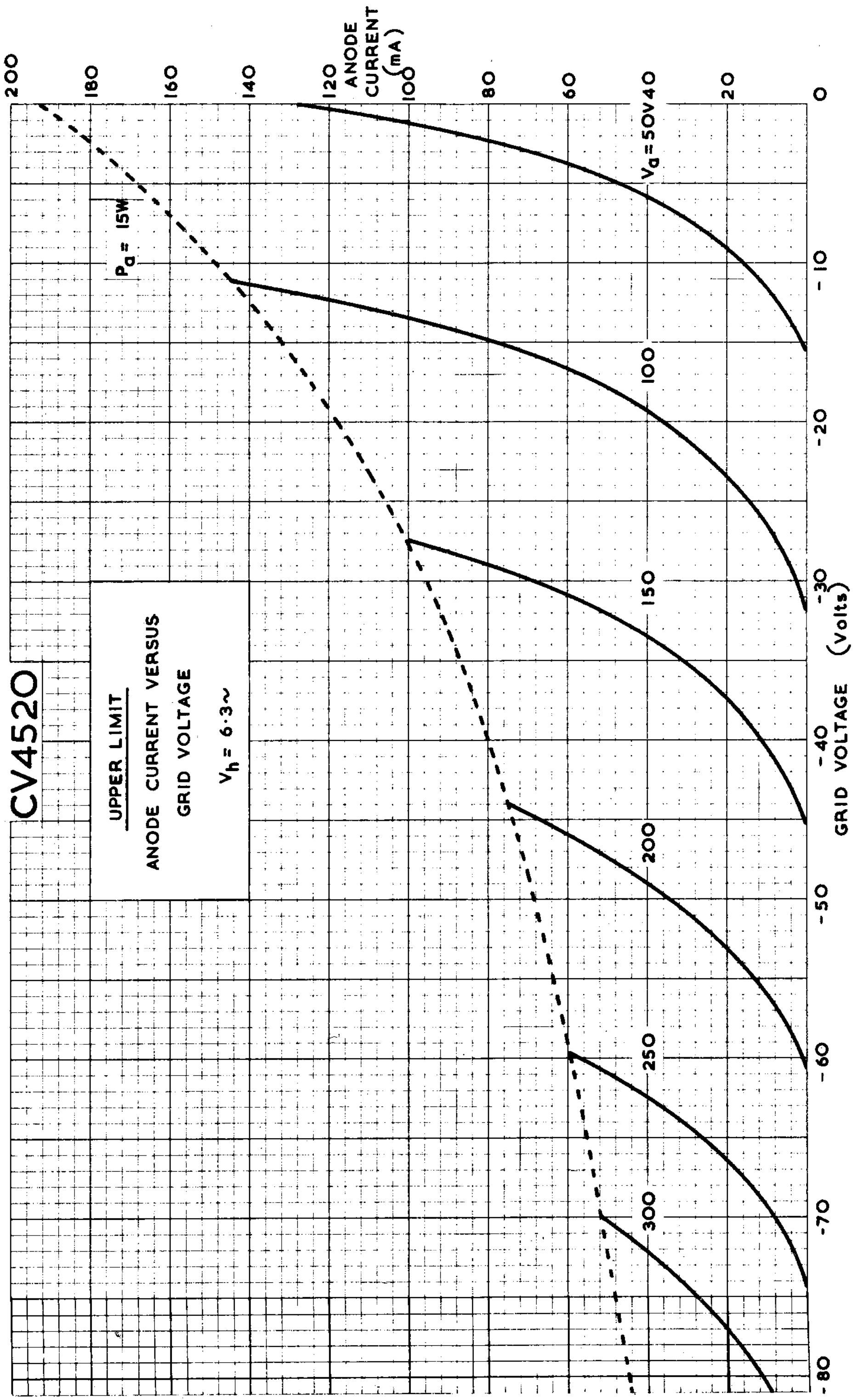
TYPICAL LIMITING DISTRIBUTION OF GRID VOLTAGE

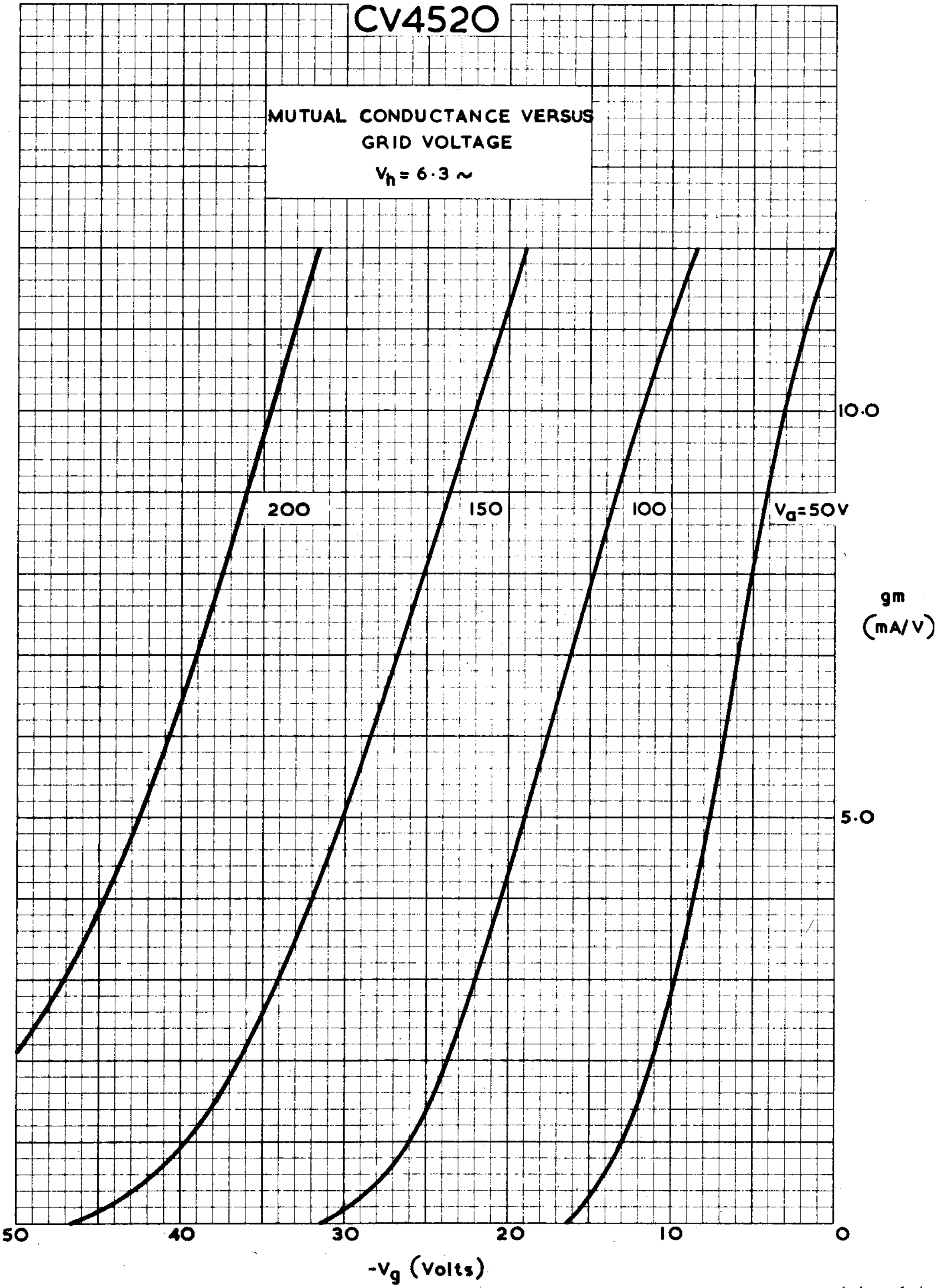


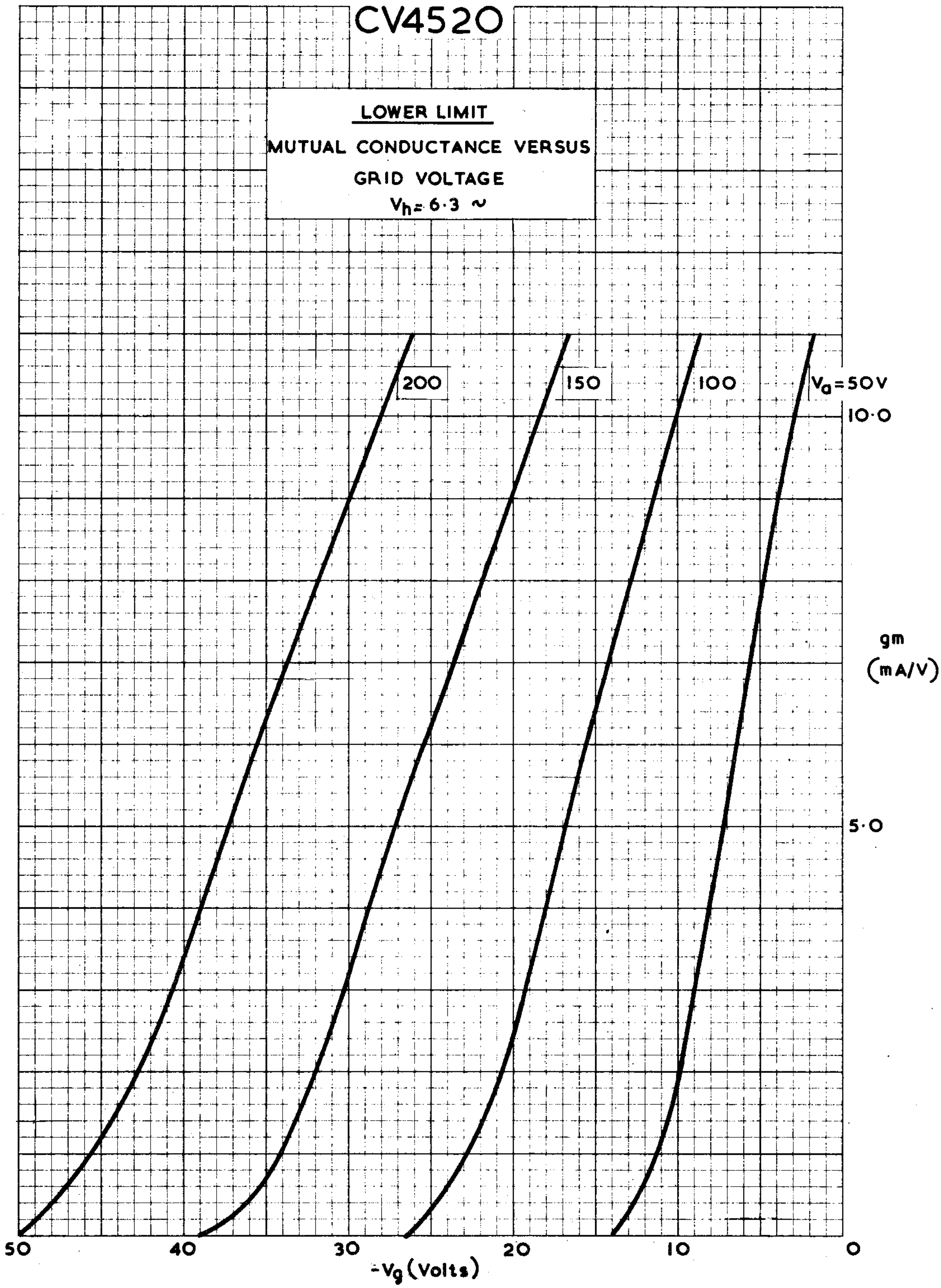
TYPICAL GAUSSIAN DISTRIBUTION OF GRID VOLTAGE

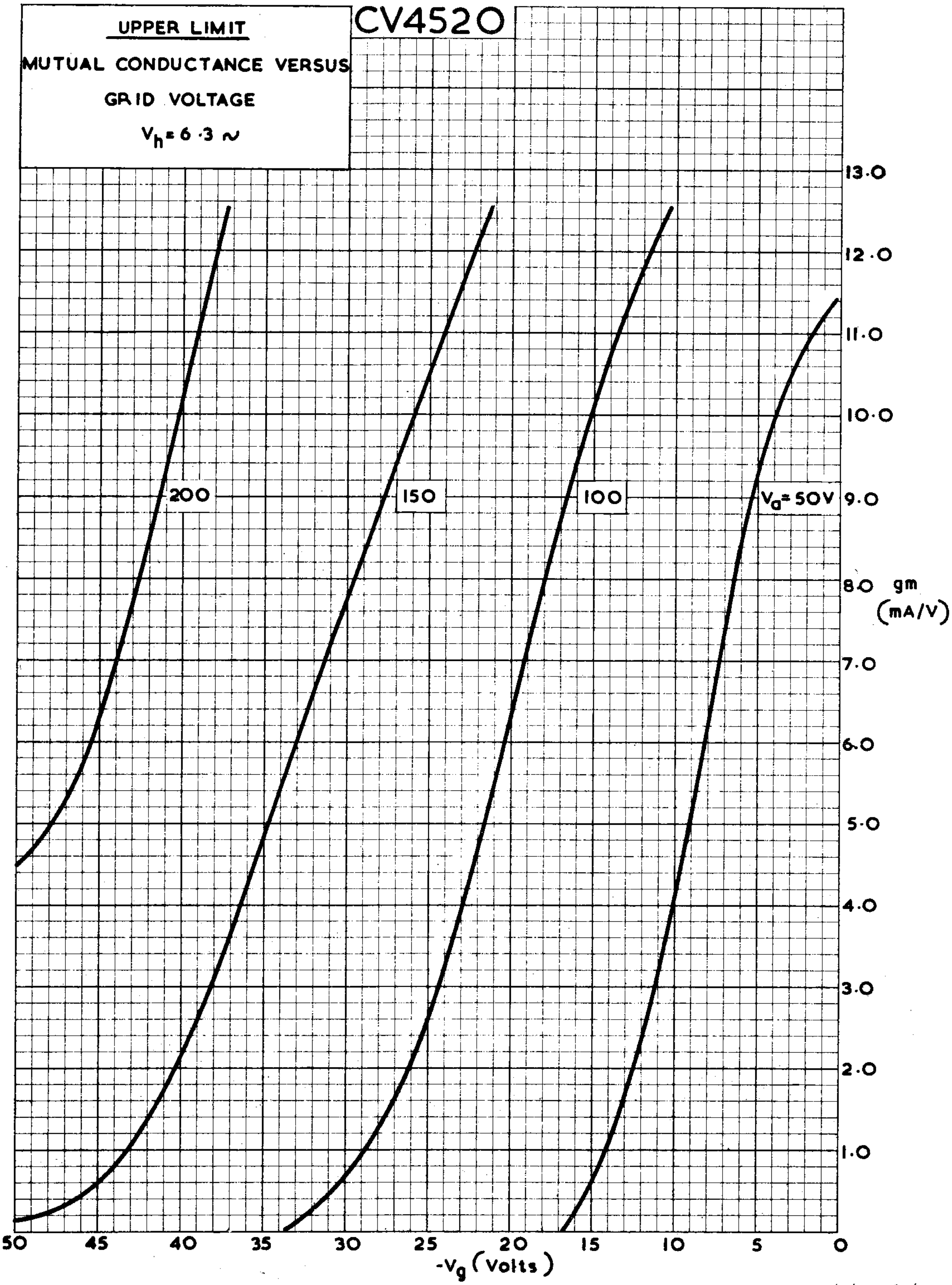

CV4520
ANODE CURRENT VERSUS GRID VOLTAGE
ANODE CURRENT (mA)
200
180
160
140
120
100
80
60
40
20
0
GRID VOLTAGE (Volts)
-10
-20
-30
-40
-50
-60
-70
-80
V_a = 50V
100
150
200
250
300
P_a = 15W

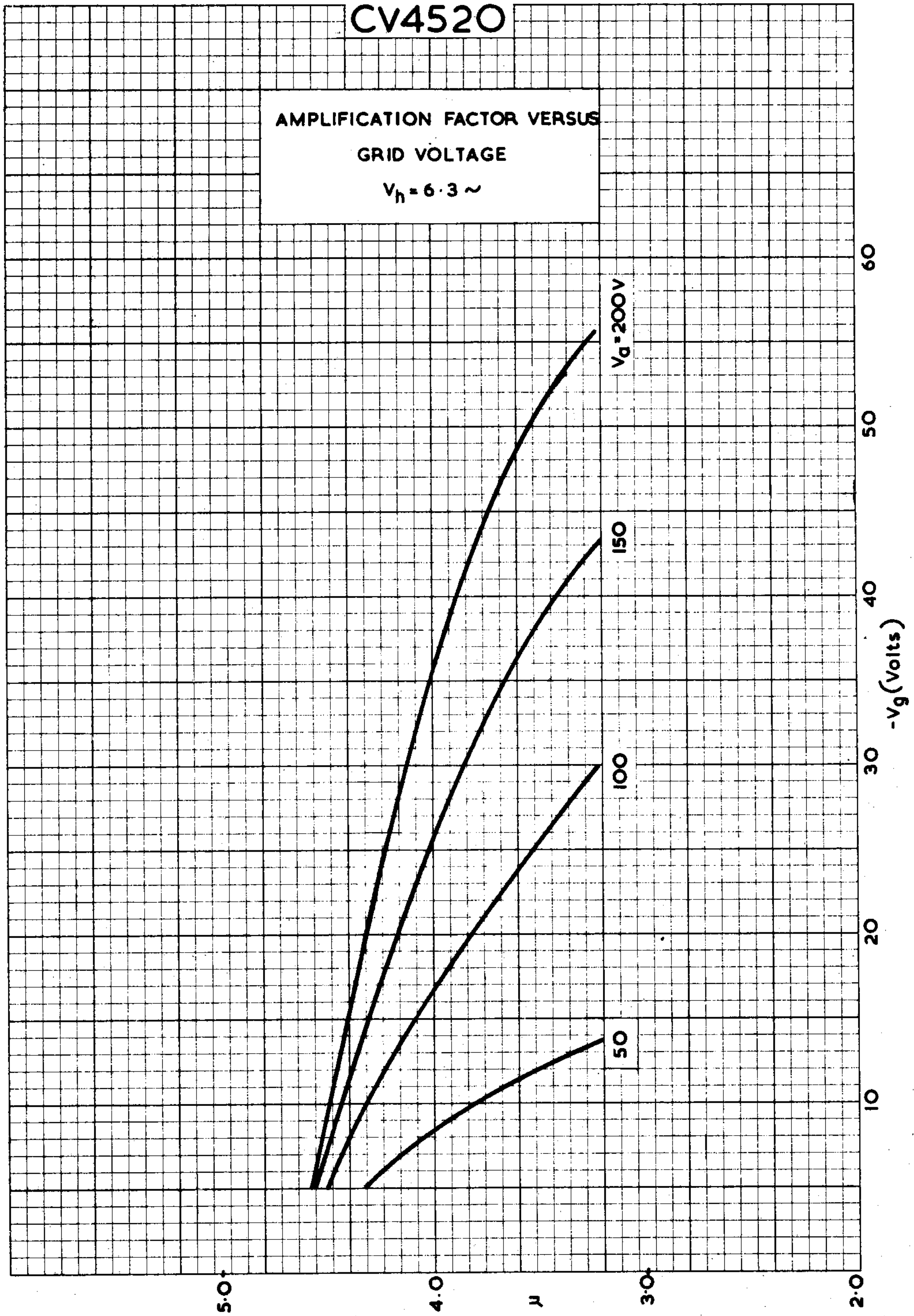

CV4520
LOWER LIMIT
ANODE CURRENT VERSUS
GRID VOLTAGE
Vh = 6·3~
ANODE CURRENT (mA)
200
180
160
140
120
100
80
60
40
20
0
GRID VOLTAGE (Volts)
0
-10
-20
-30
-40
-50
-60
-70
Pa = 15W
Va = 50V
100
150
200
250
300

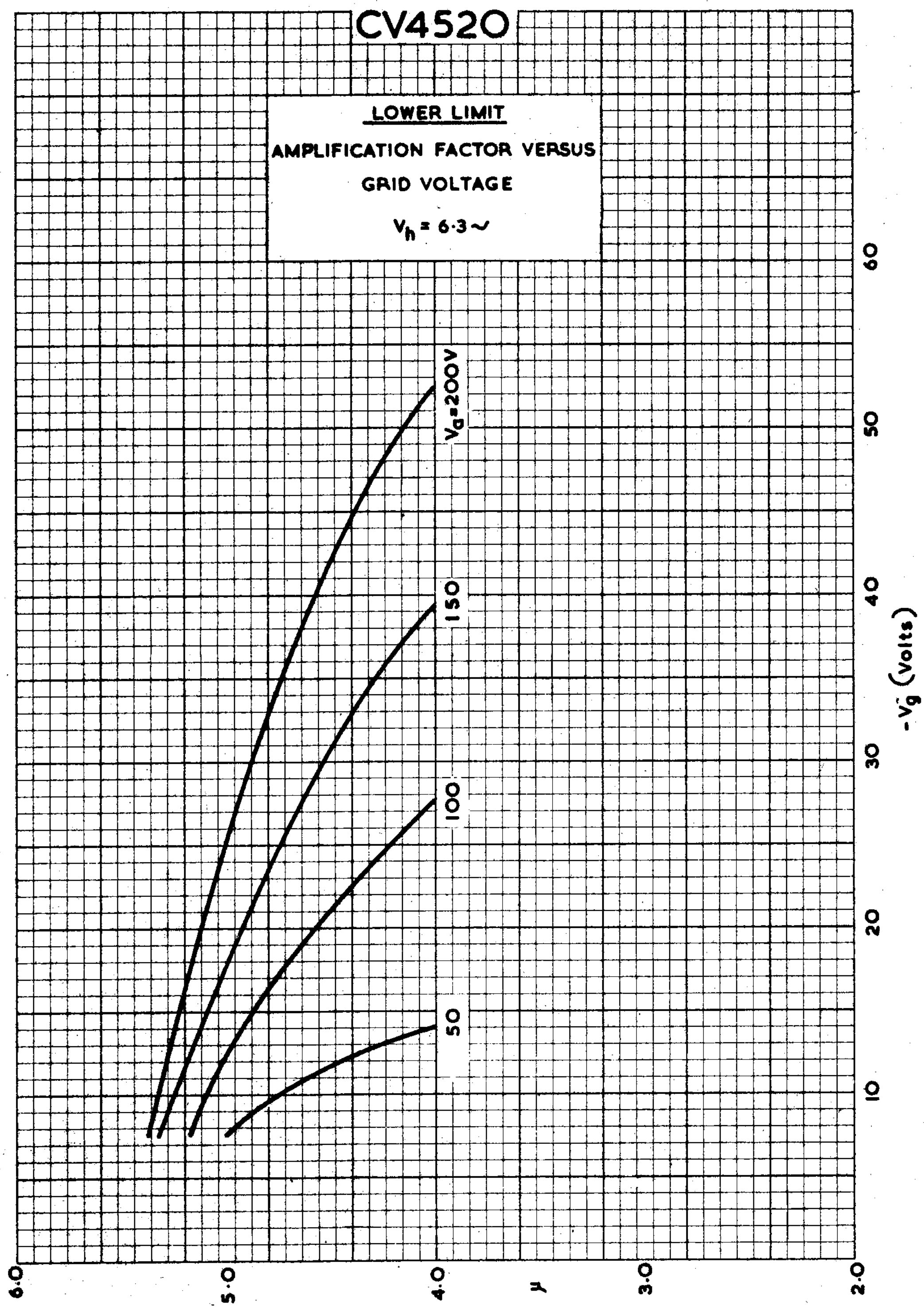

CV4520
UPPER LIMIT
ANODE CURRENT VERSUS
GRID VOLTAGE
V_h = 6·3~
P_a = 15W
V_a = 50V 40
100
150
200
250
300
ANODE CURRENT (mA)
200 180 160 140 120 100 80 60 20 0
GRID VOLTAGE (Volts)
0 -10 -20 -30 -40 -50 -60 -70 -80

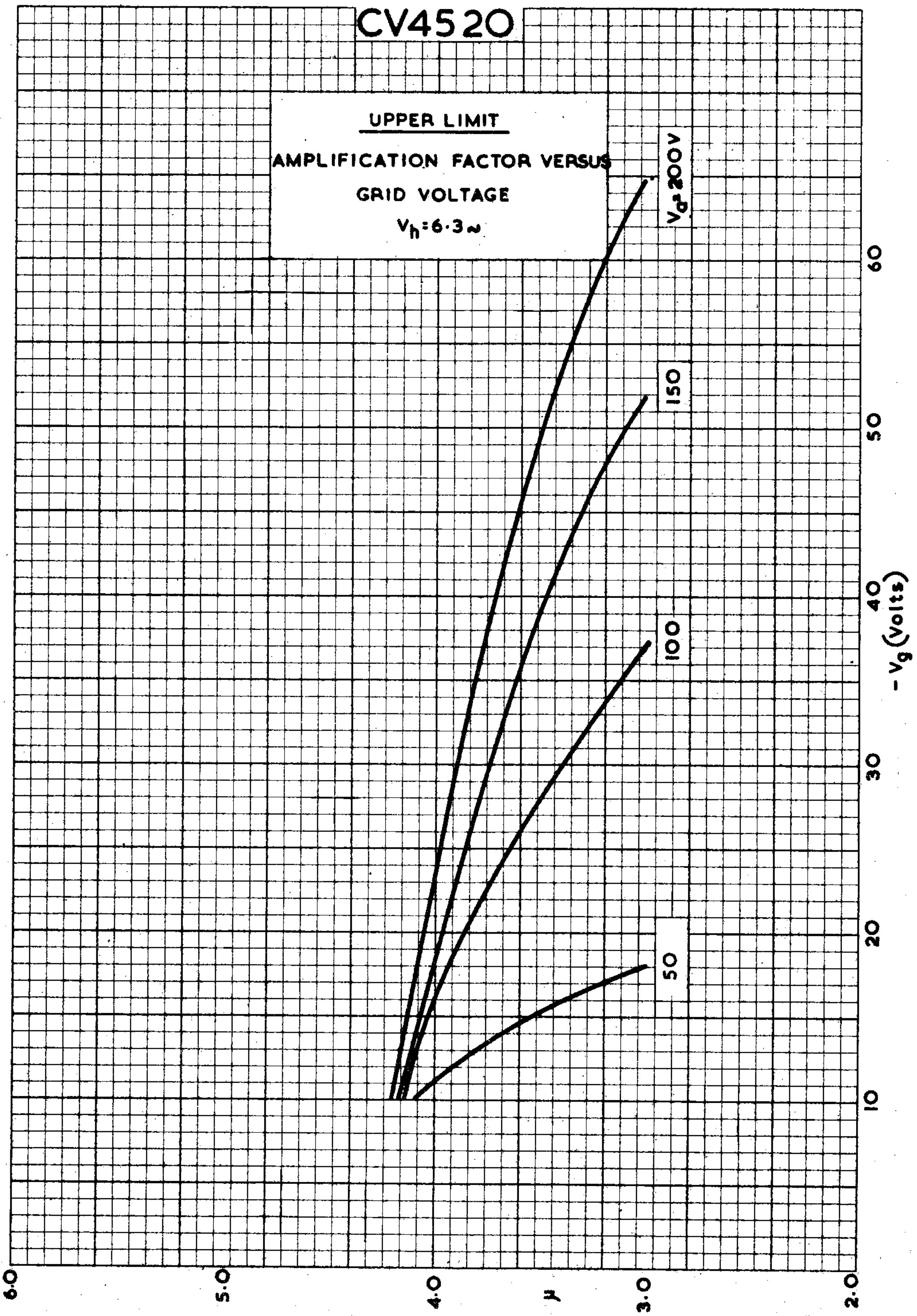

CV4520
MUTUAL CONDUCTANCE VERSUS GRID VOLTAGE
$V_h = 6 \cdot 3 \sim$
200
150
100
V_a=50V
10.0
5.0
gm (mA/V)
50
40
30
20
10
0
$-V_g$ (Volts)


CV4520
LOWER LIMIT
MUTUAL CONDUCTANCE VERSUS
GRID VOLTAGE
Vh = 6·3 ~
200
150
100
Va = 50V
10·0
5·0
gm
(mA/V)
50
40
30
20
10
0
-Vg (Volts)


CV4520
UPPER LIMIT
MUTUAL CONDUCTANCE VERSUS
GRID VOLTAGE
Vh=6·3 ~
200
150
100
Va=50V
13.0
12.0
11.0
10.0
9.0
8.0
gm
(mA/V)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
50
45
40
35
30
25
20
15
10
5
0
-Vg (Volts)


CV4520
AMPLIFICATION FACTOR VERSUS
GRID VOLTAGE
Vh = 6·3 ~
Va = 200V
150
100
50
60
50
40
30
20
10
-Vg (Volts)
5·0
4·0
μ
3·0
2·0


CV4520
LOWER LIMIT
AMPLIFICATION FACTOR VERSUS
GRID VOLTAGE
Vh = 6·3~
Va=200V
150
100
50
6·0
5·0
4·0
μ
3·0
2·0
10
20
30
40
50
60
-Vg (Volts)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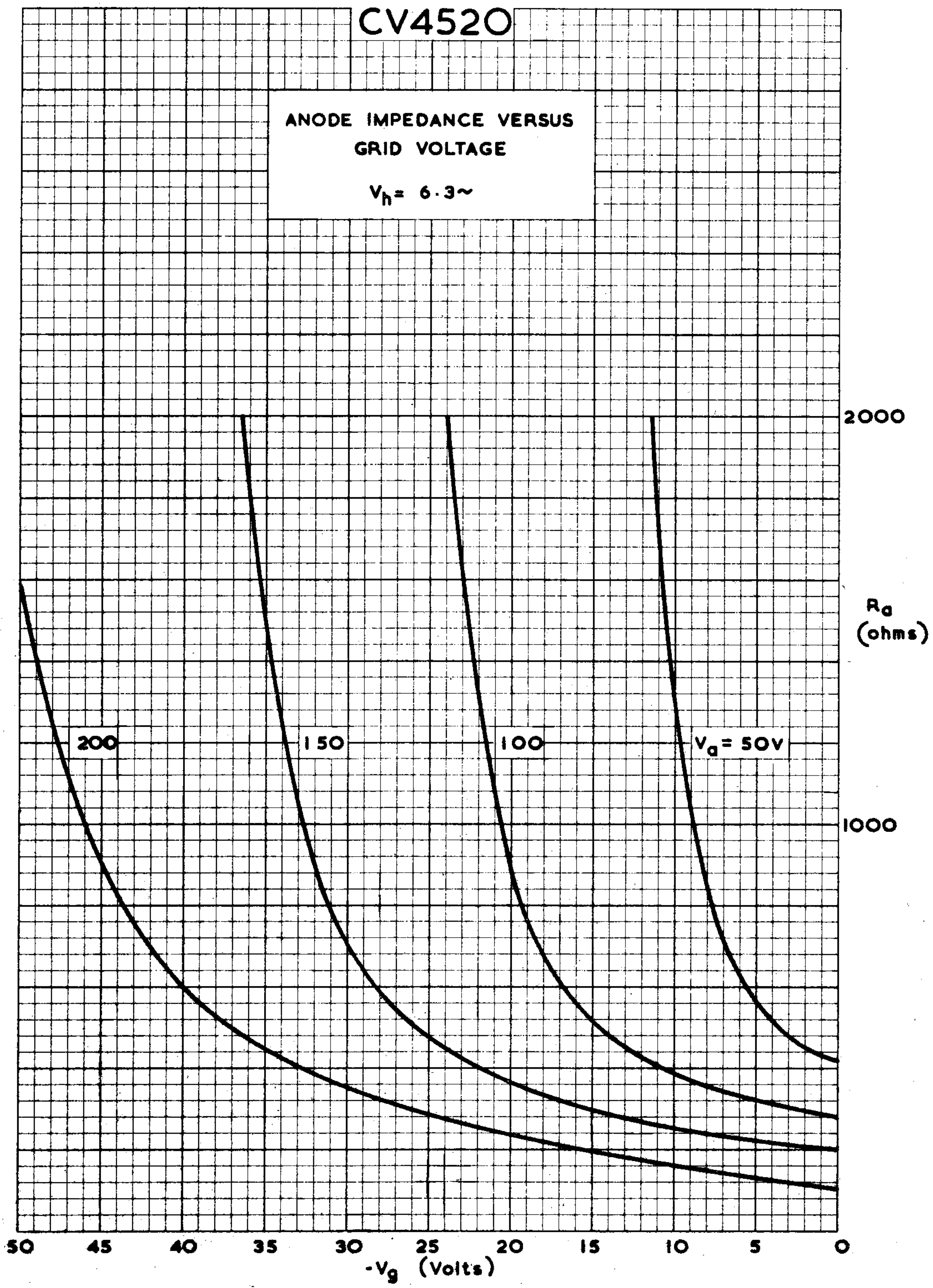
UPPER LIMIT
AMPLIFICATION FACTOR VERSUS
GRID VOLTAGE
$V_h = 6 \cdot 3 \sim$
$V_a = 200V$
150
100
50
60
50
40
30
20
10
$-V_g$ (Volts)
6.0
5.0
4.0
μ
3.0
2.0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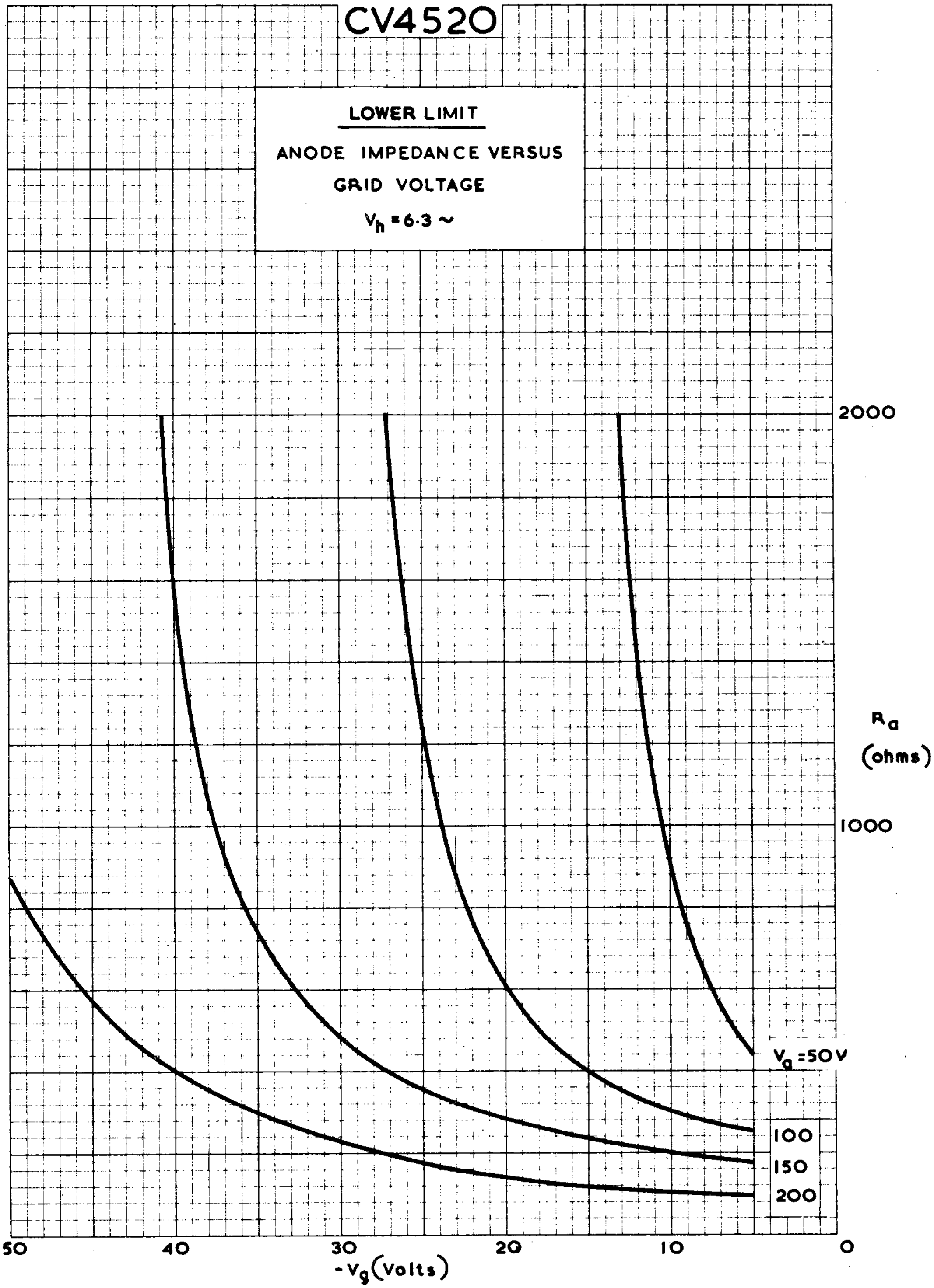
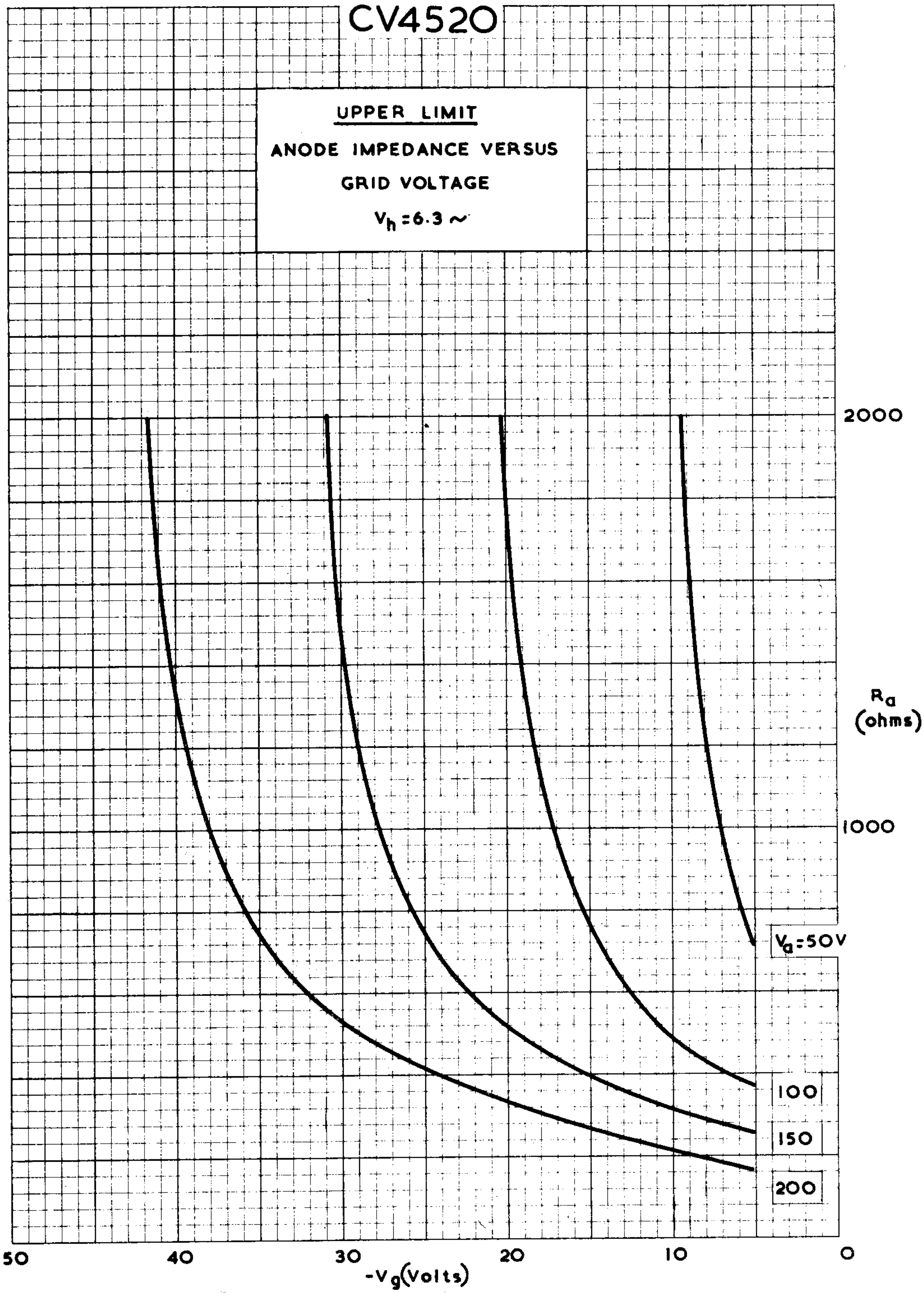
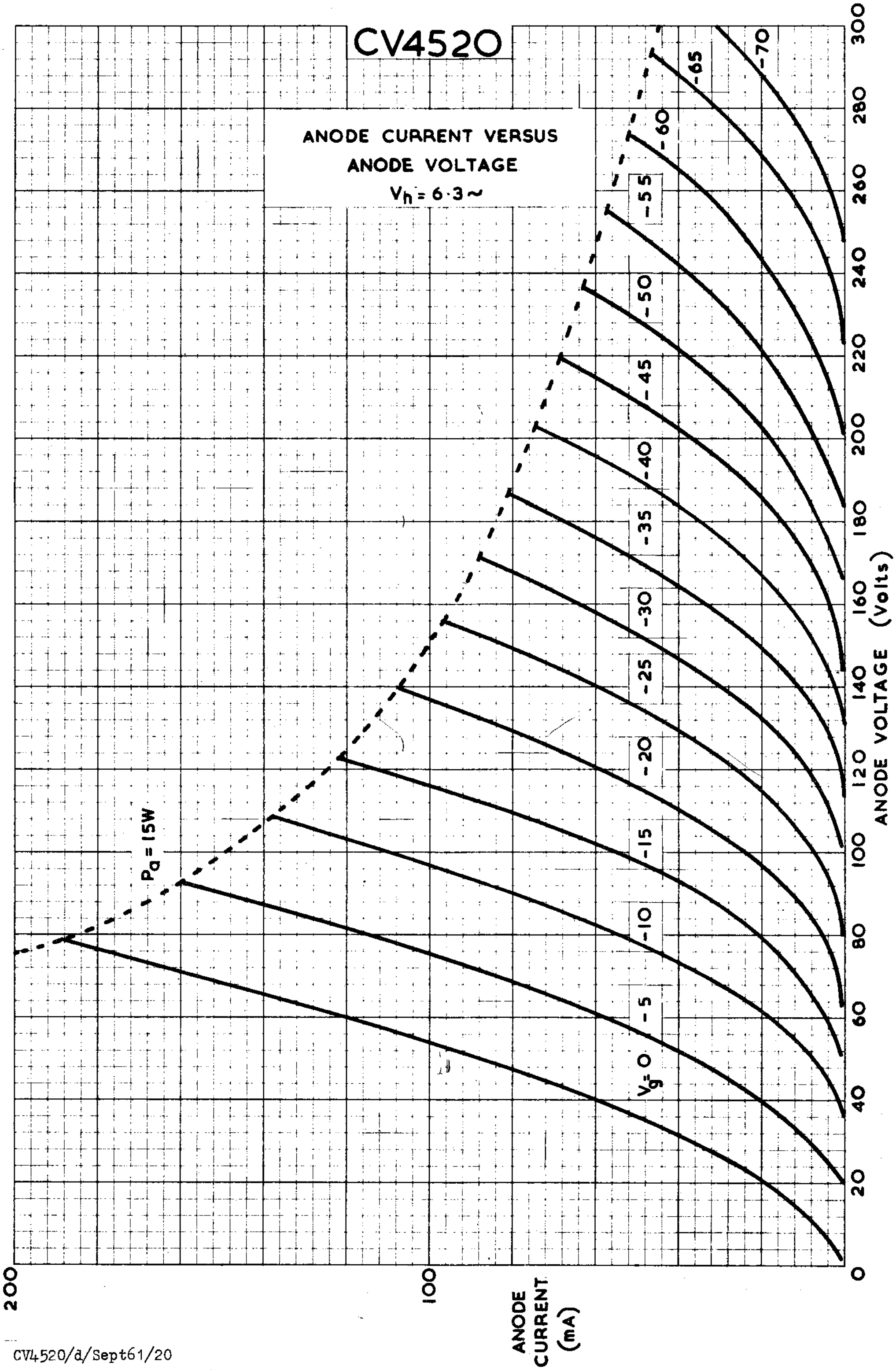
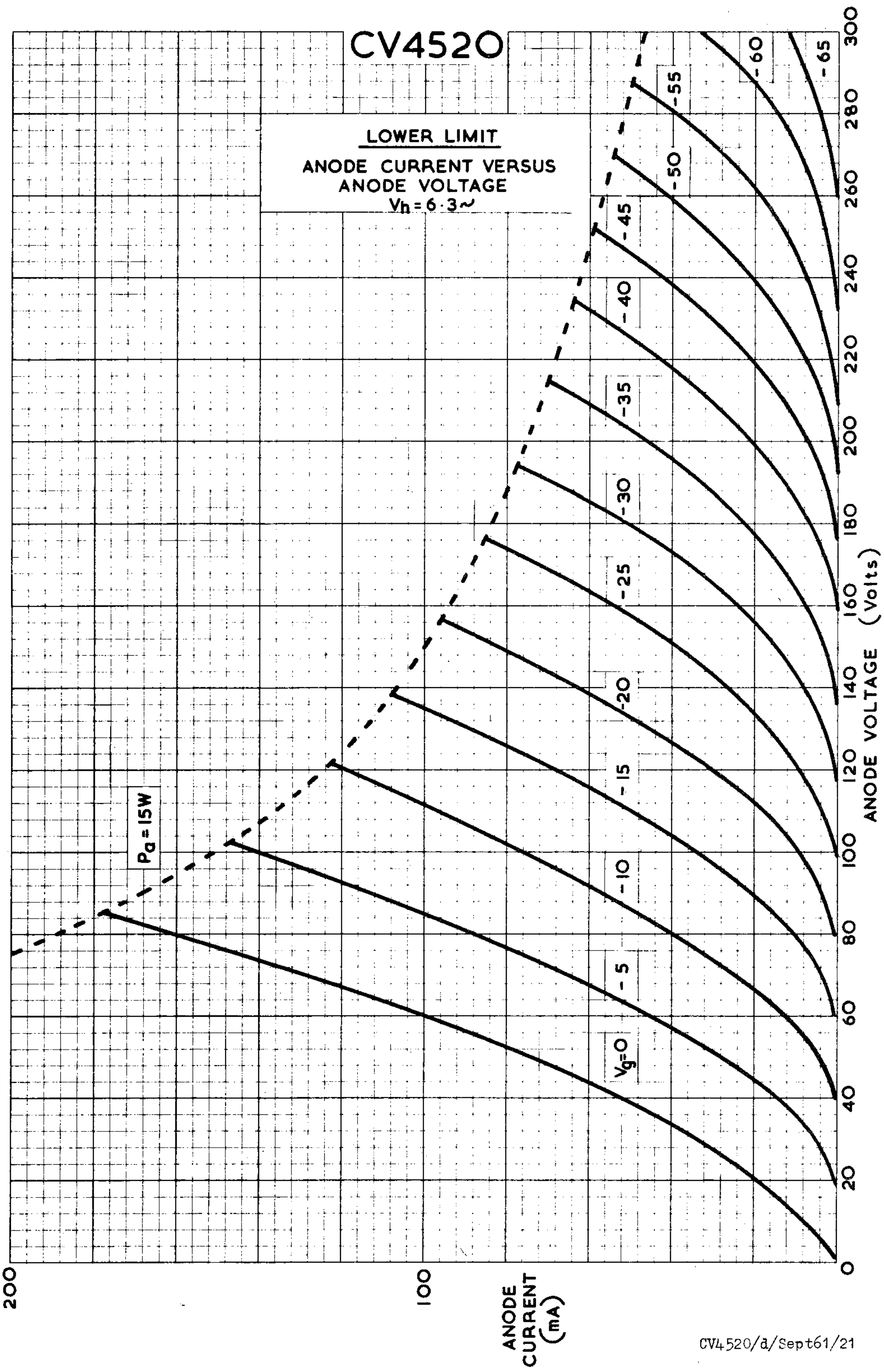
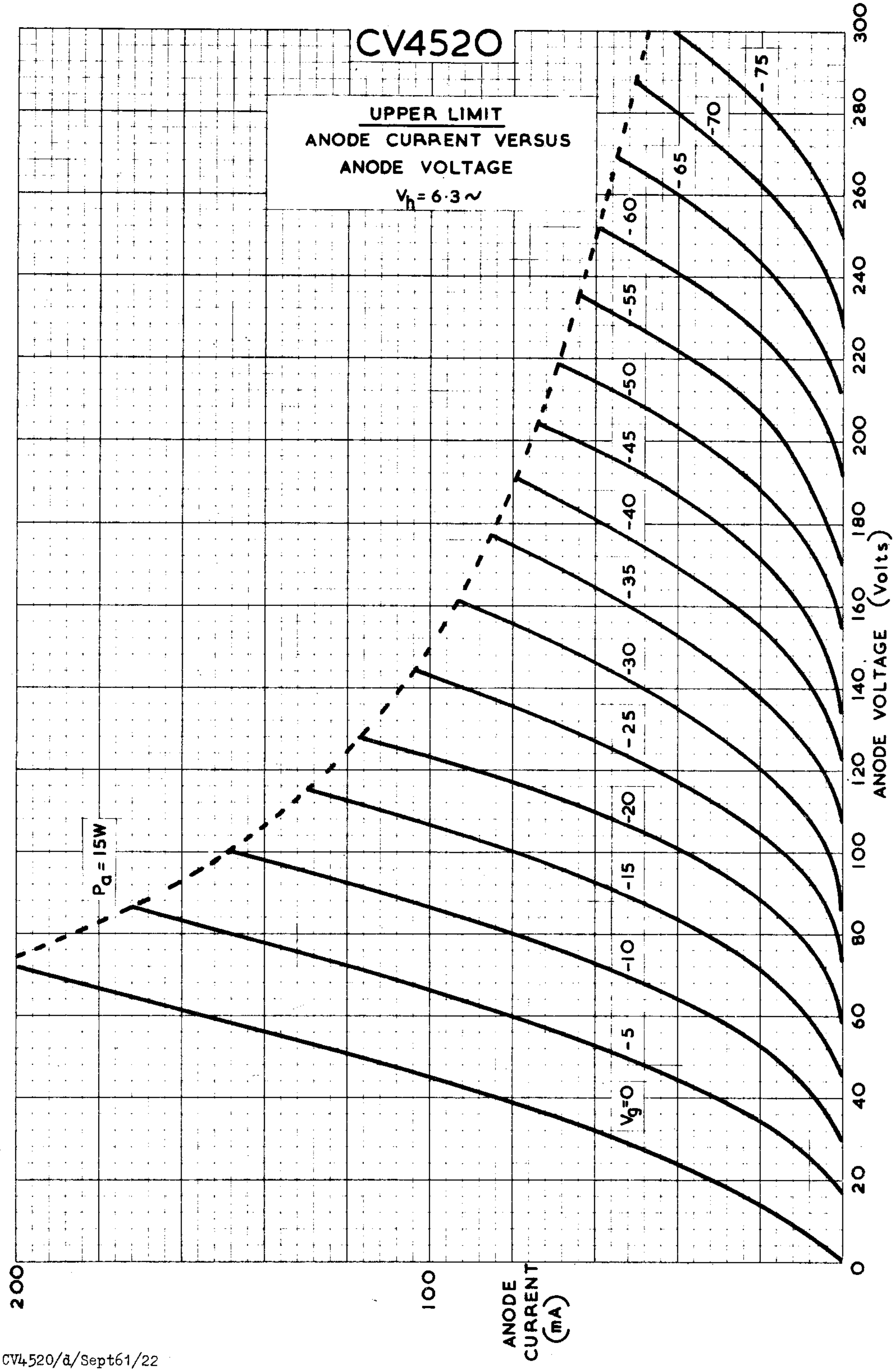
ANODE IMPEDANCE VERSUS
GRID VOLTAGE
Vh= 6·3~
2000
Ra
(ohms)
200
150
100
Va= 50V
1000
50
45
40
35
30
25
20
15
10
5
0
-Vg (Volts)


CV4520
LOWER LIMIT
ANODE IMPEDANCE VERSUS
GRID VOLTAGE
Vh = 6·3 ~
2000
1000
Ra
(ohms)
Va = 50V
100
150
200
50
40
30
20
10
0
-Vg (Volts)

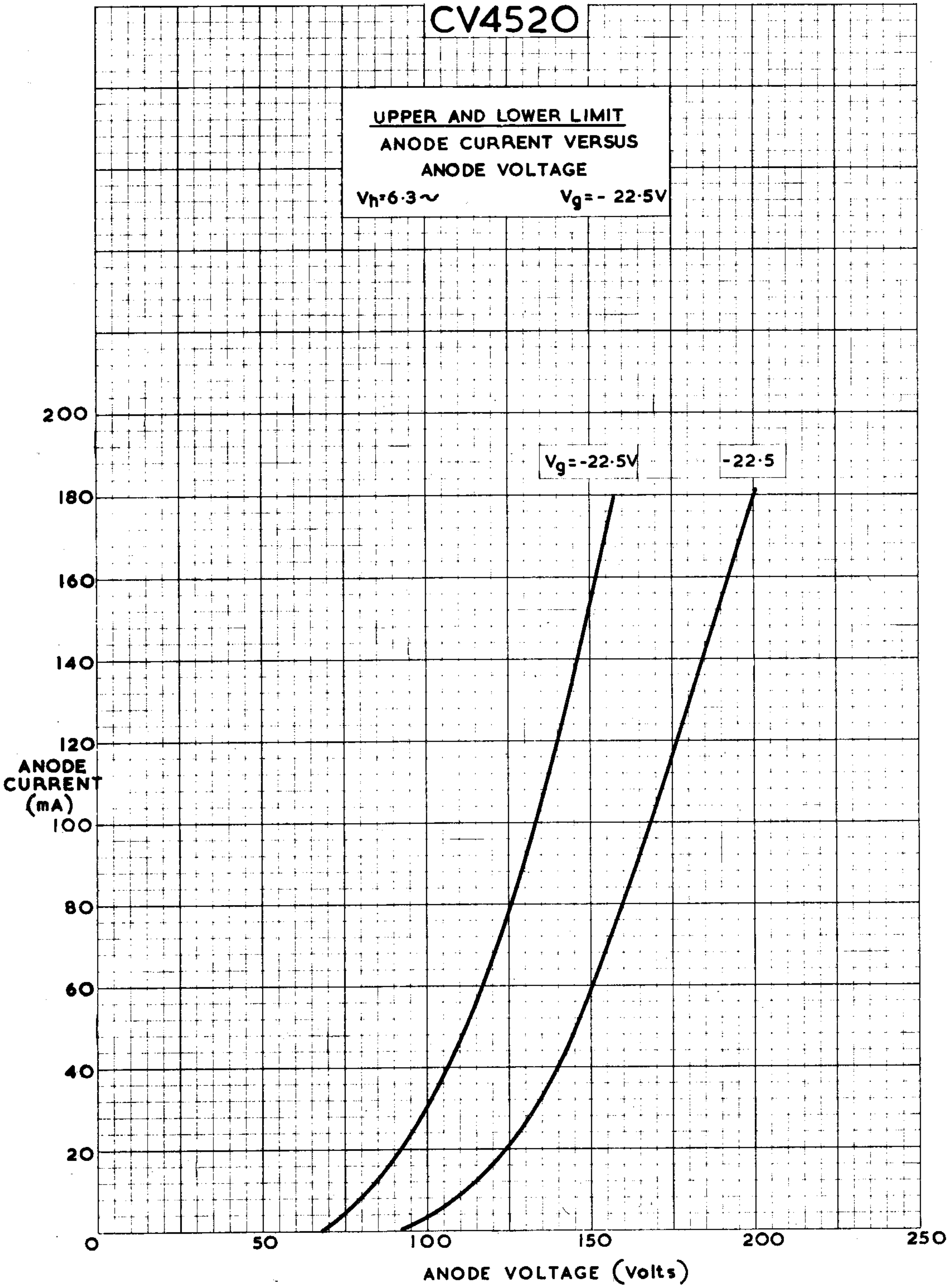

CV4520
UPPER LIMIT
ANODE IMPEDANCE VERSUS
GRID VOLTAGE
Vh = 6.3 ~
2000
Ra
(ohms)
1000
Va = 50V
100
150
200
50
40
30
20
10
0
-Vg(Volts)

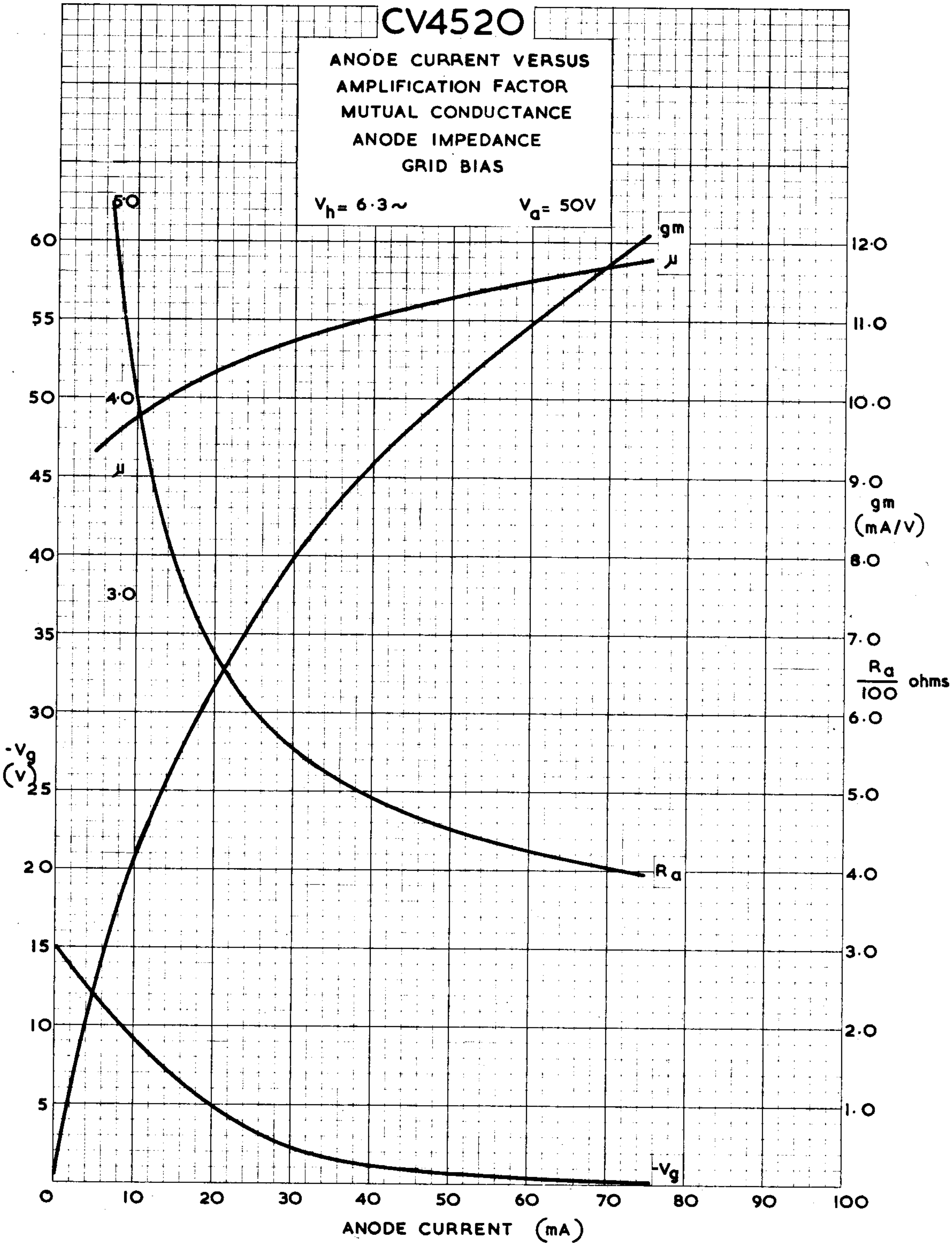

CV4520
ANODE CURRENT VERSUS
ANODE VOLTAGE
Vh = 6·3 ~
Pa = 15W
Vg = 0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
ANODE VOLTAGE (Volts)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
ANODE CURRENT (mA)
200
100

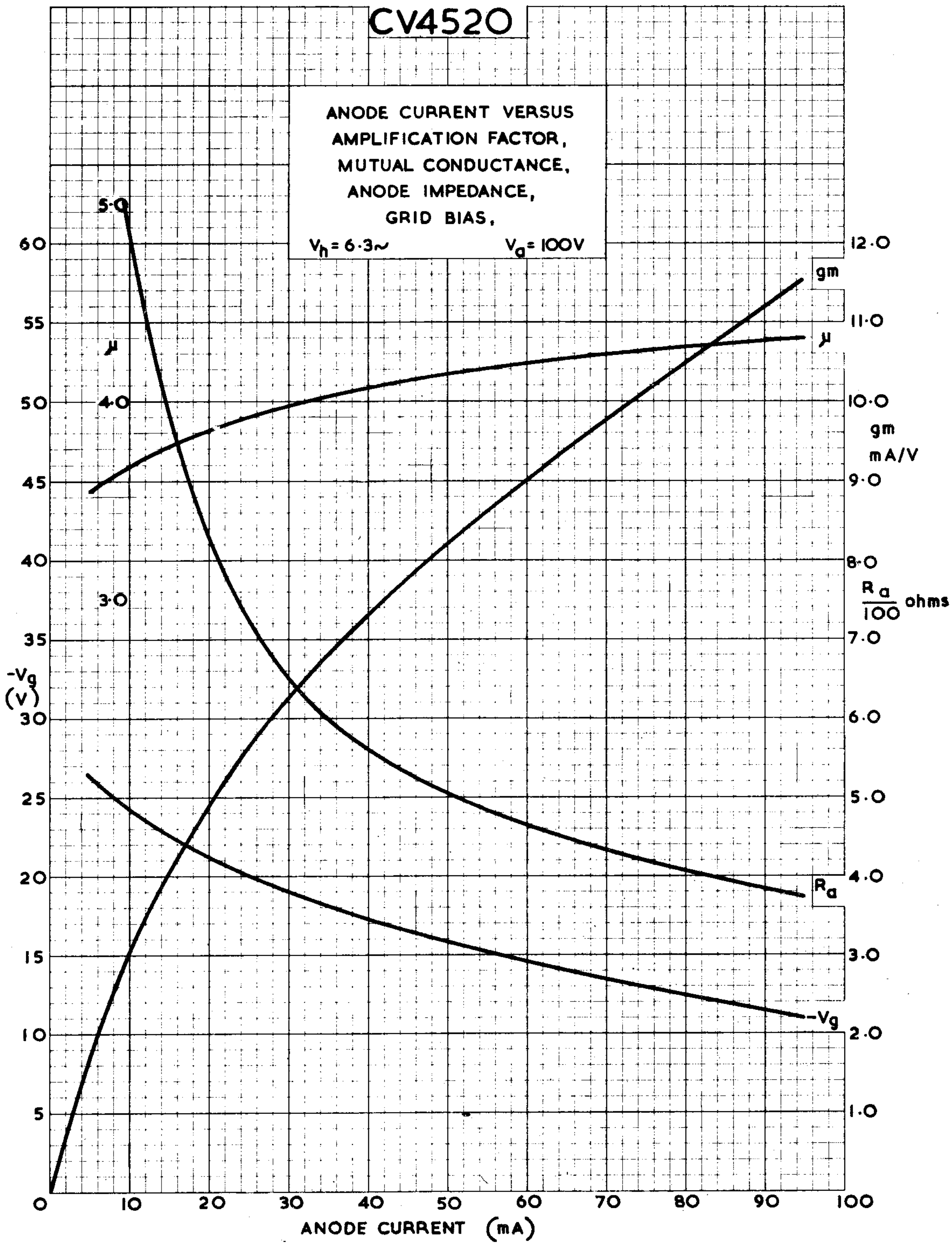

CV4520
LOWER LIMIT
ANODE CURRENT VERSUS
ANODE VOLTAGE
Vh = 6·3~
Pa = 15W
Vg=0
- 5
- 10
- 15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
ANODE VOLTAGE (Volts)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
ANODE CURRENT (mA)
200
100

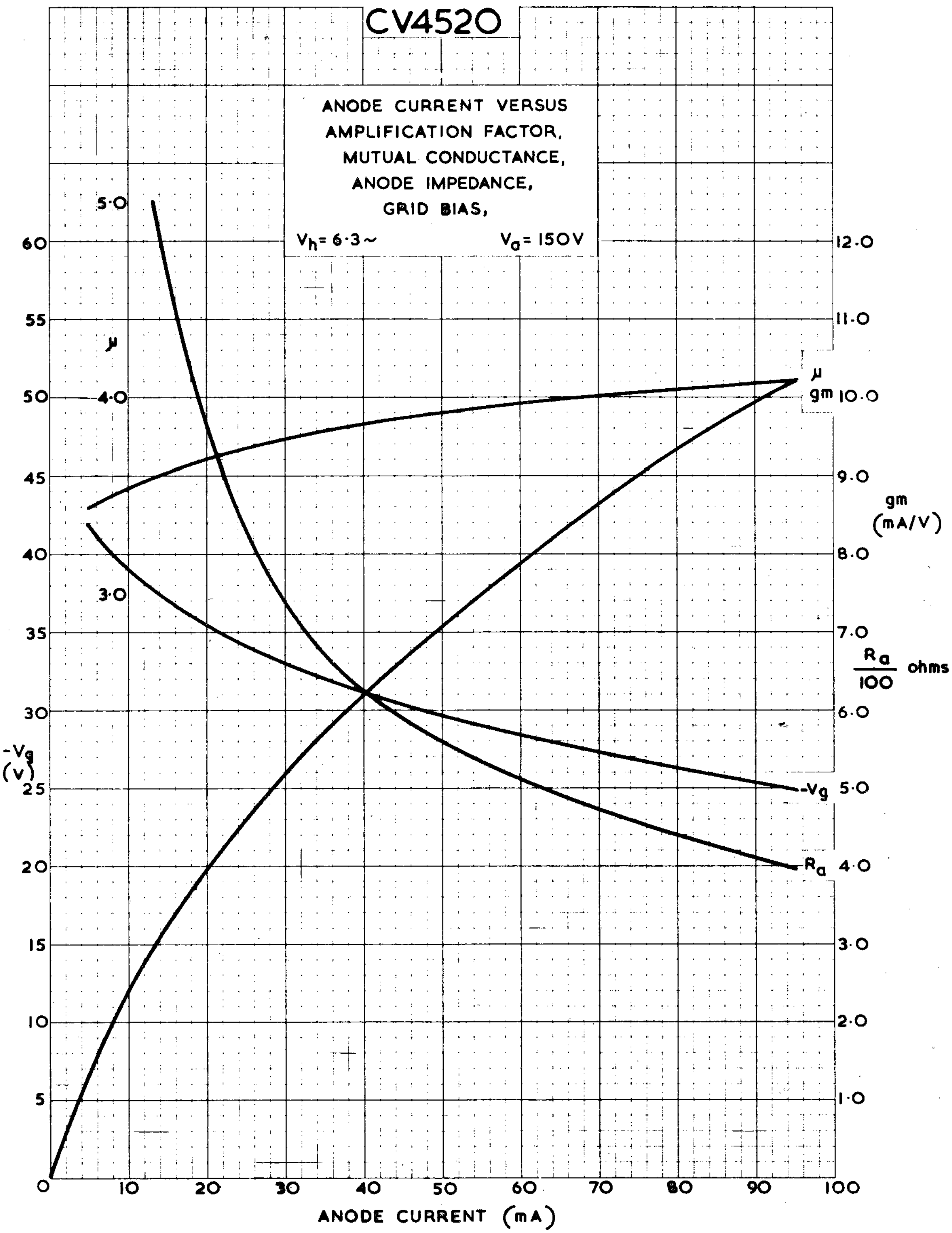


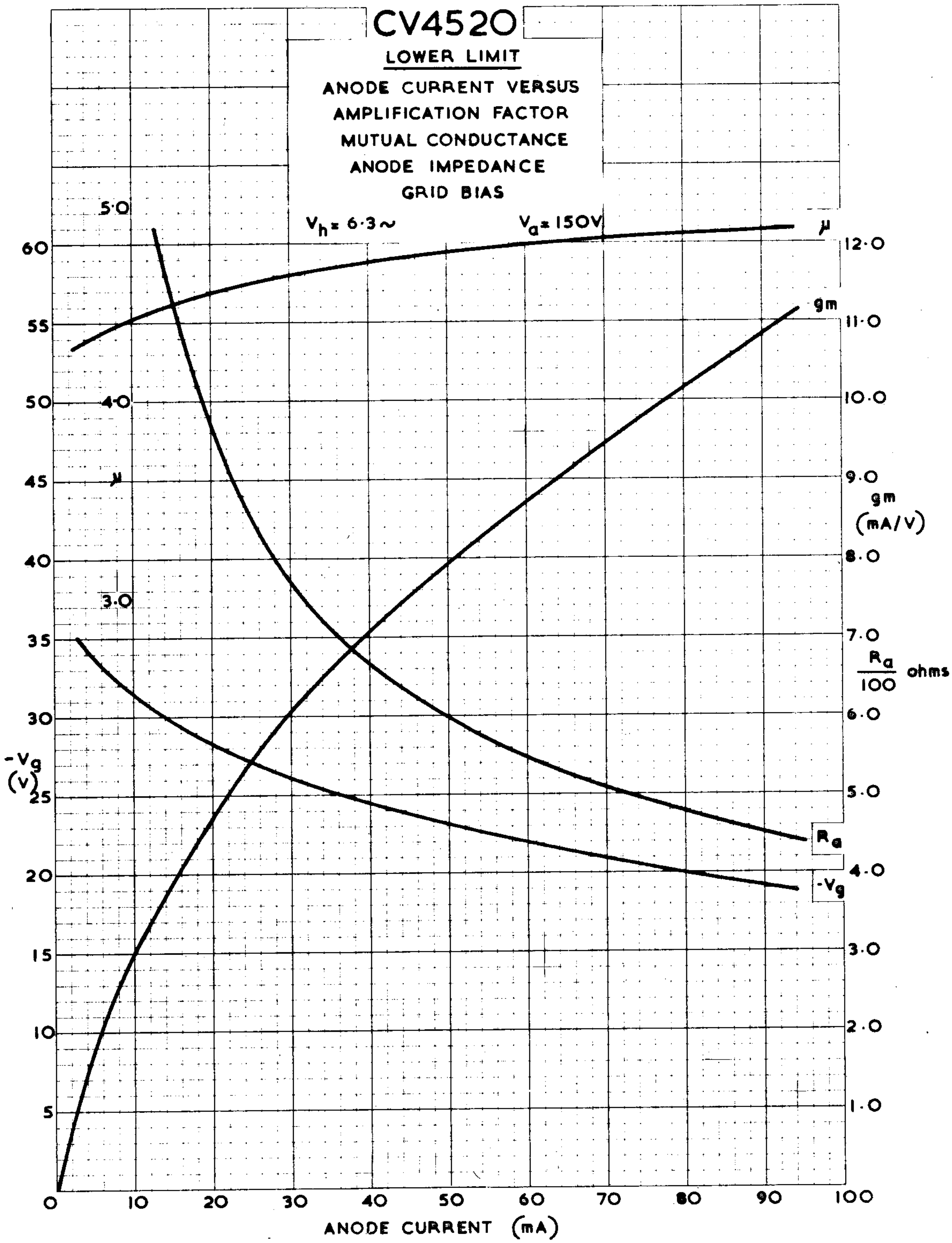
CV4520
UPPER LIMIT
ANODE CURRENT VERSUS
ANODE VOLTAGE
V_h = 6·3 ~
P_a = 15W
V_g=0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
ANODE VOLTAGE (Volts)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
ANODE CURRENT (mA)
200
100

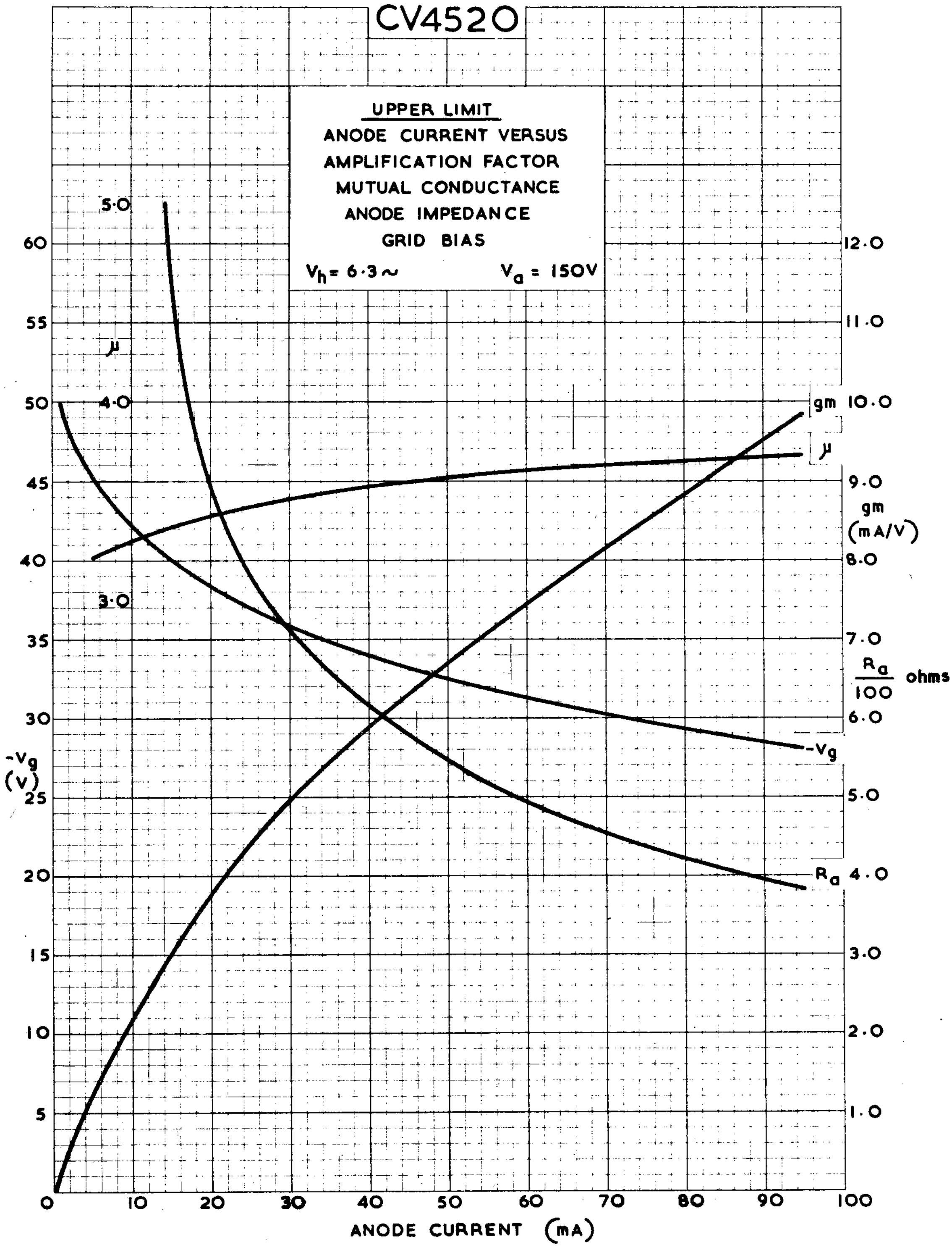

CV4520
UPPER AND LOWER LIMIT
ANODE CURRENT VERSUS
ANODE VOLTAGE
Vh=6·3~
Vg=- 22·5V
Vg=-22·5V
-22·5
ANODE CURRENT (mA)
200
180
160
140
120
100
80
60
40
20
0
50
100
150
200
250
ANODE VOLTAGE (Volts)

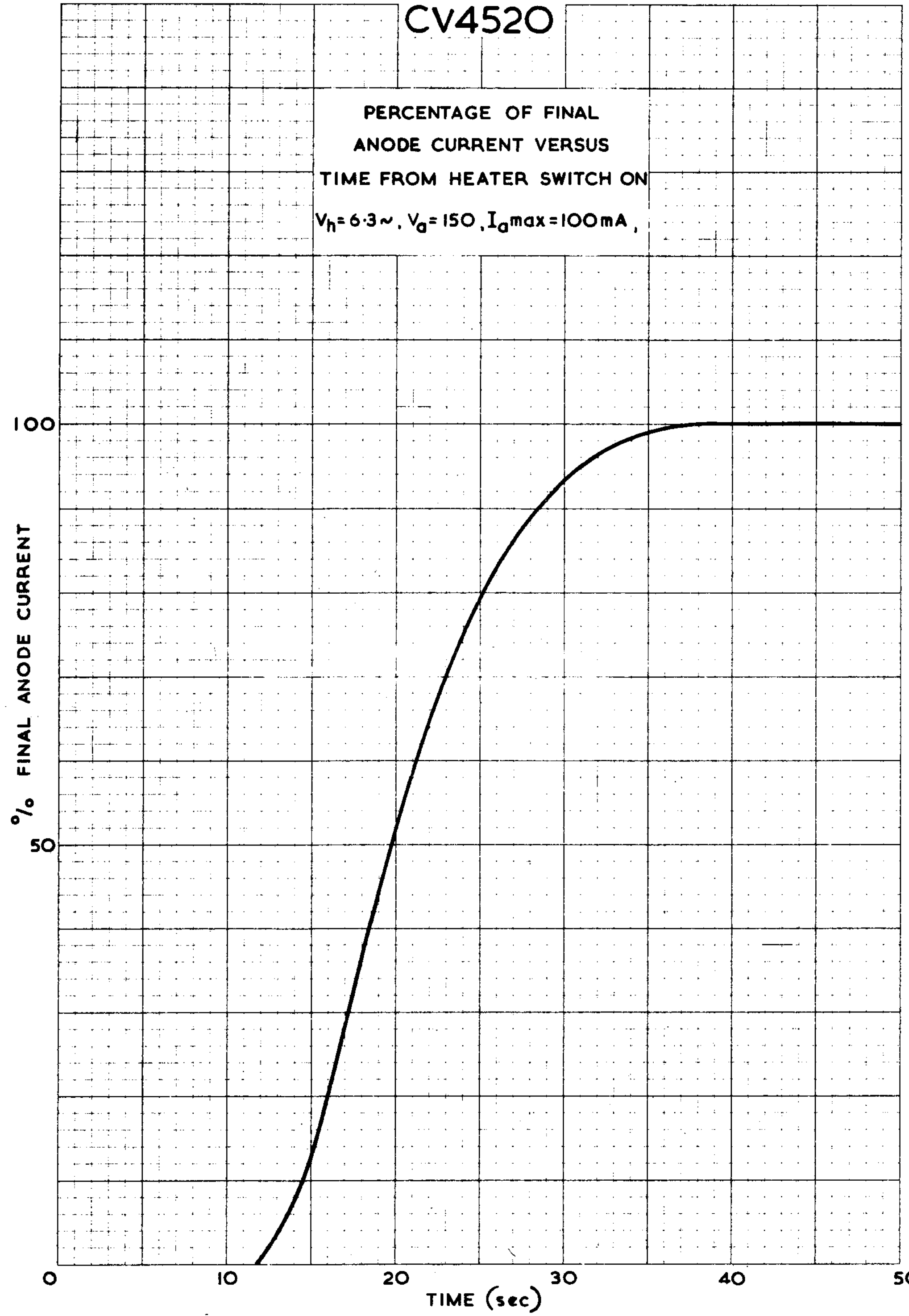

CV4520
ANODE CURRENT VERSUS
AMPLIFICATION FACTOR
MUTUAL CONDUCTANCE
ANODE IMPEDANCE
GRID BIAS
V_h = 6·3 ~
V_a = 50V
gm
μ
R_a
$-V_g$
5·0
4·0
3·0
60
55
50
45
40
35
30
25
20
15
10
5
$-V_g$ (V)
12·0
11·0
10·0
9·0
8·0
7·0
6·0
5·0
4·0
3·0
2·0
1·0
gm (mA/V)
$\frac{R_a}{100}$ ohms
0
10
20
30
40
50
60
70
80
90
100
ANODE CURRENT (mA)


CV4520
ANODE CURRENT VERSUS
AMPLIFICATION FACTOR,
MUTUAL CONDUCTANCE,
ANODE IMPEDANCE,
GRID BIAS,
Vh = 6·3~
Va = 100V
-Vg (V)
μ
gm mA/V
Ra/100 ohms
gm
Ra
-Vg
5·0
4·0
3·0
0
5
10
15
20
25
30
35
40
45
50
55
60
1·0
2·0
3·0
4·0
5·0
6·0
7·0
8·0
9·0
10·0
11·0
12·0
10
20
30
40
50
60
70
80
90
100
ANODE CURRENT (mA)


CV4520
ANODE CURRENT VERSUS
AMPLIFICATION FACTOR,
MUTUAL CONDUCTANCE,
ANODE IMPEDANCE,
GRID BIAS,
V_h= 6·3~
V_a= 150V
5·0
4·0
3·0
μ
60
55
50
45
40
35
30
25
20
15
10
5
0
-V_g
(V)
12·0
11·0
10·0
9·0
8·0
7·0
6·0
5·0
4·0
3·0
2·0
1·0
μ
gm
-V_g
R_a
gm
(mA/V)
R_a/100 ohms
10
20
30
40
50
60
70
80
90
100
ANODE CURRENT (mA)


CV4520
LOWER LIMIT
ANODE CURRENT VERSUS
AMPLIFICATION FACTOR
MUTUAL CONDUCTANCE
ANODE IMPEDANCE
GRID BIAS
Vh = 6·3 ~
Va = 150V
μ
gm
Ra
-Vg
-Vg (V)
μ
gm (mA/V)
Ra/100 ohms
5·0
4·0
3·0
60
55
50
45
40
35
30
25
20
15
10
5
12·0
11·0
10·0
9·0
8·0
7·0
6·0
5·0
4·0
3·0
2·0
1·0
0
10
20
30
40
50
60
70
80
90
100
ANODE CURRENT (mA)


CV4520
UPPER LIMIT
ANODE CURRENT VERSUS
AMPLIFICATION FACTOR
MUTUAL CONDUCTANCE
ANODE IMPEDANCE
GRID BIAS
Vh = 6·3 ~
Va = 150V
μ
5·0
4·0
3·0
60
55
50
45
40
35
30
25
20
15
10
5
-Vg (V)
12·0
11·0
10·0
9·0
8·0
7·0
6·0
5·0
4·0
3·0
2·0
1·0
gm
μ
gm (mA/V)
Ra/100 ohms
-Vg
Ra
0
10
20
30
40
50
60
70
80
90
100
ANODE CURRENT (mA)


CV4520
PERCENTAGE OF FINAL
ANODE CURRENT VERSUS
TIME FROM HEATER SWITCH ON
Vh= 6·3 ~, Va= 150, Ia max = 100 mA,
100
50
% FINAL ANODE CURRENT
0
10
20
30
40
50
TIME (sec)

MAXIMUM VALUE OF GRID-TO-CATHODE RESISTOR

The value of the external grid to cathode resistor which can be used with a valve in circuit is limited by the negative grid current of the valve and the D.C. effective mutual conductance of the valve in the circuit.

In simple circuits, the maximum safe value of grid to cathode resistor can be obtained with the aid of the curves given on the next page, by taking the working slope from characteristic curves and calculating the value of the effective cathode resistor from the following equations:-

For Triodes:- $$Rk\ eff. = Rk + \frac{Ra}{\mu}$$

For Pentodes:- $$Rk\ eff. = \frac{Ik \times Rk}{Ia} + \frac{Ig2 \times Rg2}{Ia \times \mu(g1 - g2)}$$

Example

CV4502 operating as a voltage amplifier with Va(b)=250V, Ra=100K, Rg2=330K, Rk=560. Ia=2.0mA, Ig2=0.67mA, gm working=3.5mA/V.

$$\text{Then } Rk\ eff. = \frac{2.67 \times 560}{2.0} + \left(\frac{0.67}{2.0} \times \frac{330,000}{28}\right)$$

$$= 4715 \text{ ohms.}$$

From the curves for these values of Rk eff. and gm working:-

$$\frac{Rg1\ (maximum)}{Rg1\ (max)\ (Fixed\ bias\ published)} \times \frac{gm\ (working)}{gm\ (published)} = 16$$

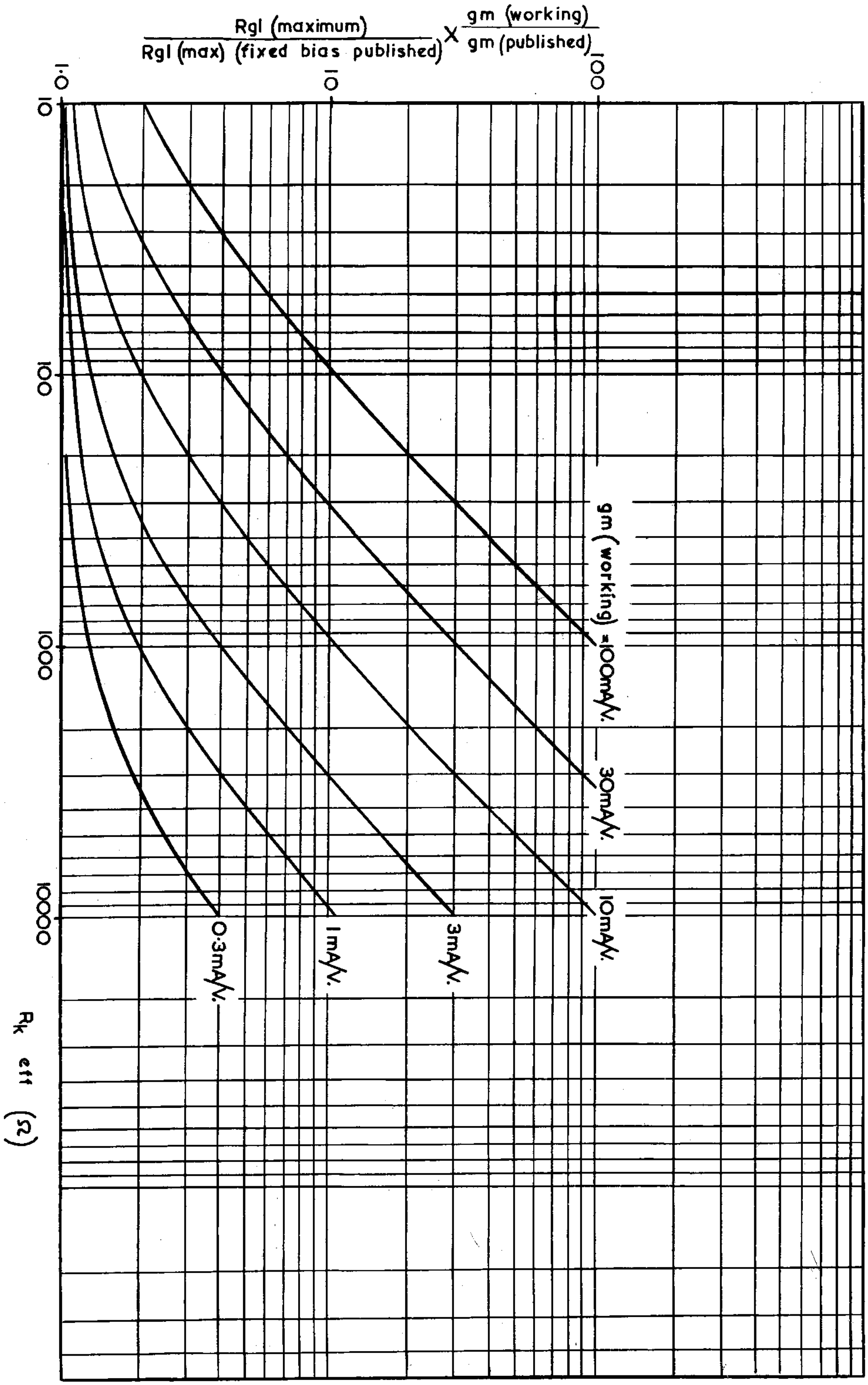
$$\text{Therefore } Rg1 \text{ maximum} = 16 \times 0.25 \times 10^6 \times \frac{5.2}{3.5} = 6M.$$

In more complex circuits, for example, those employing feedback additional to that given by a cathode, anode or screen grid resistor, or those having large signals and driven into positive grid current, the working slope and effective cathode resistor are difficult to assess. For these cases the maximum value of grid to cathode resistor in circuit is given by the following relationship:-

$$\frac{Rg1\ (maximum)}{Rg1\ (max)\ (fixed\ bias\ published)} = \frac{gm\ (published)}{gm\ (w:\ eff.)}$$

where the effective working mutual conductance gm (w: eff:) is obtained by measurement in the circuit and is the change of anode current that would occur in that circuit for unit change of grid voltage, where this change of voltage is that which would be caused by a change of negative grid current within the valve.

CV4520



Rgl (maximum) / Rgl (max) (fixed bias published) X gm (working) / gm (published)
1·0
10
100
10
100
1000
10000
gm (working) =100mA/V.
30mA/V.
10mA/V.
3mA/V.
1mA/V.
0·3mA/V.
Rk eff (Ω)