ELECTRONIC VALVE SPECIFICATIONS

SPECIFICATION MOA/CV4503

ISSUE 2 DATED 18TH MAY 1960

AMENDMENT NO. 1

1 Amend 'No. of Pages' to read '6'
Amend Specification Authority to read 'D.L.R.D.(T)/R.R.E.
In 'Applications Data' box amend 'Page 7' to read 'Page 6'

4 Group E Vibration Noise (2) Amend 'Inspection Level' column to read 'Code L'
Group E Vibration Noise (3) Amend UAL column for 'Frequency Band 3 (250-500 c/s)' to read '300'

6 Note 12 Amend last sentence to read 'See pages 7 and 8 of CV4504'

7 Remove and destroy page 7

1962 D.L.R.D.(T)

88

APPLICATIONS DATA

FOR

VALVE TYPE

CV 4503

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

ISSUE 1 JUNE 1960

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

AMENDMENTS

No:	Date	Page

CONTENTS.

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

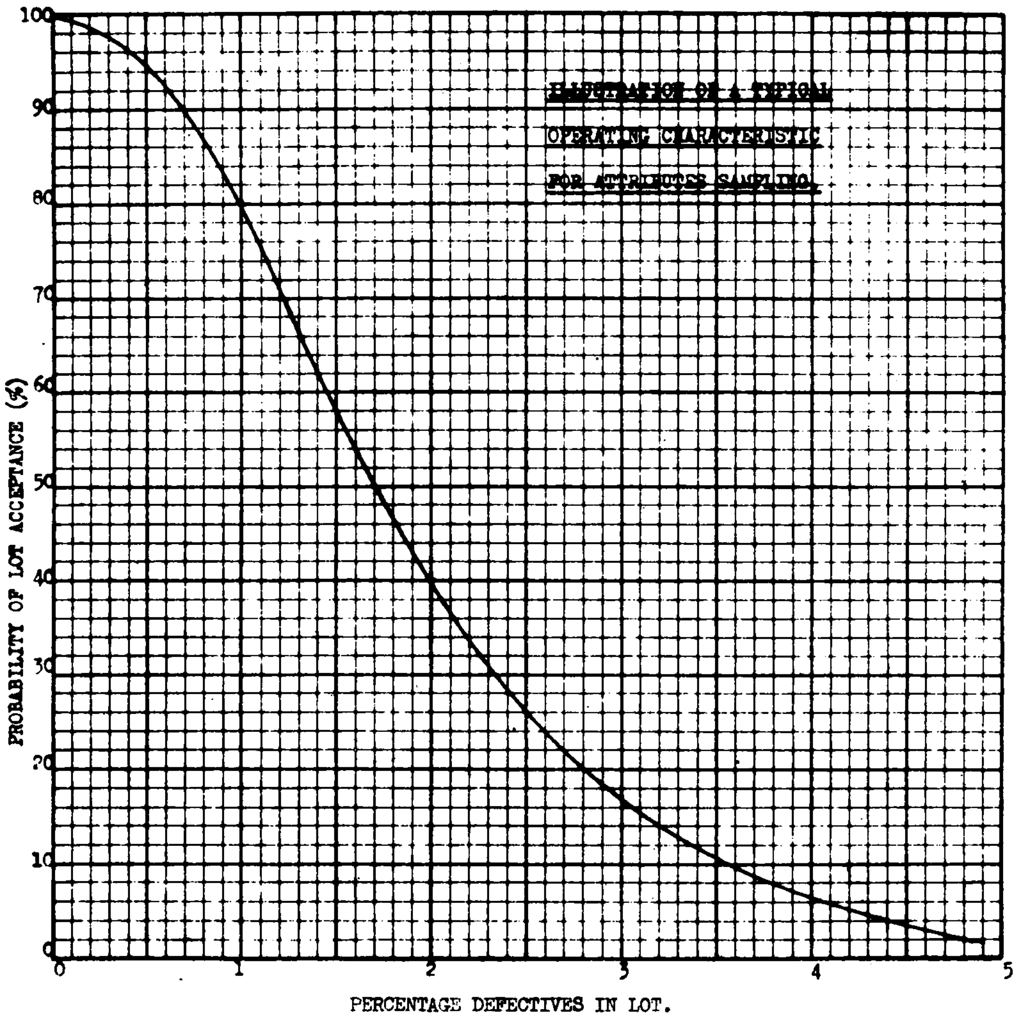
Illustrations of the limiting distributions for this valve, which would be just accepted by the above controls, are given on Pages 6 and 7. These show normal curves with the maximum permissible spread allowed by the ALD, centered on the LAL and UAL, respectively, and the maximum spread distributions,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

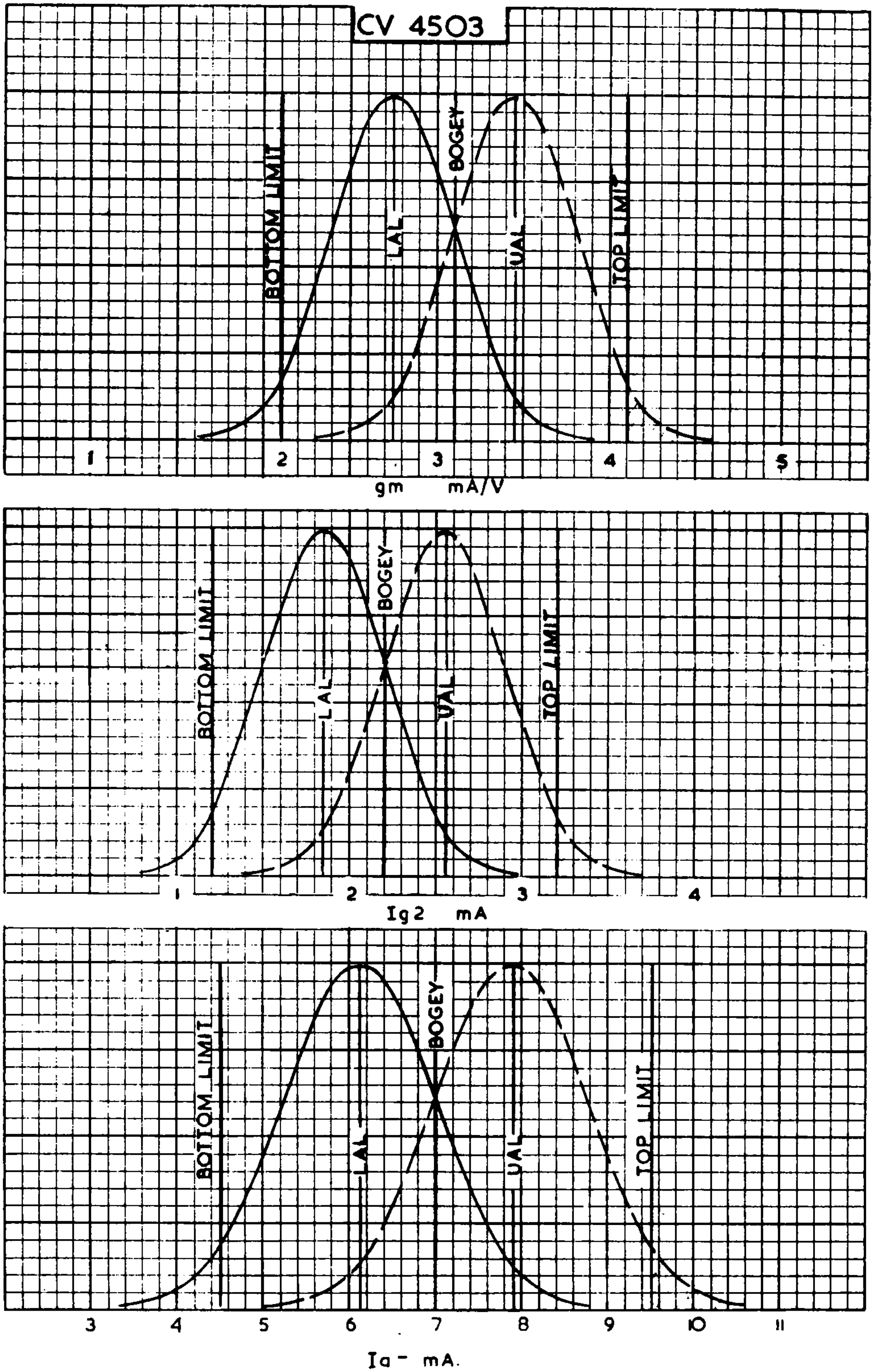
For further details of sampling inspection procedures for Attributes and Variables, reference should be made to K1001, Appendix XI, and MIL Standard 105A, Sampling Procedures and Tables for Inspection by Attributes.

Typical Operating Characteristic

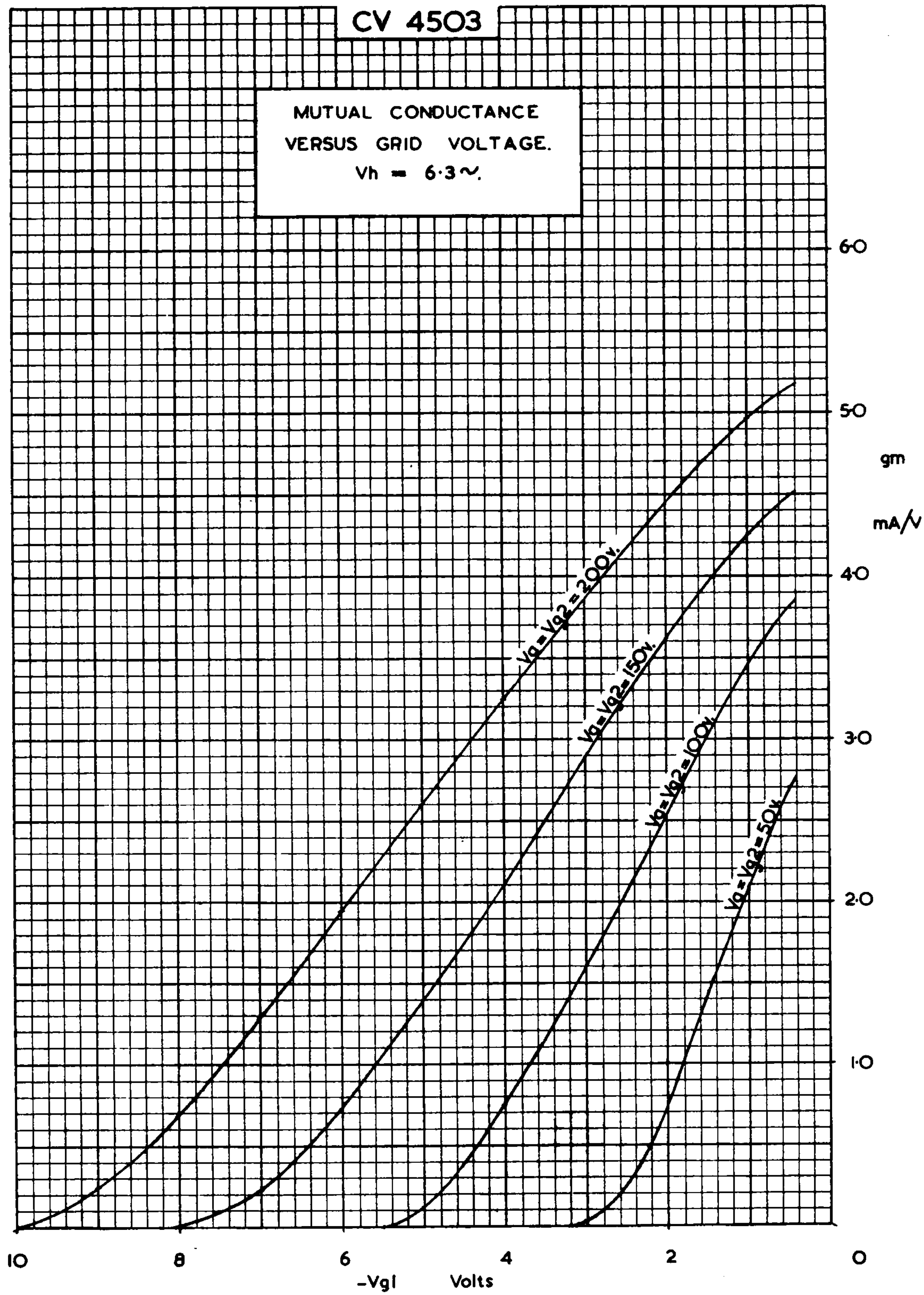
The following curve gives a typical Operating Characteristic for:-

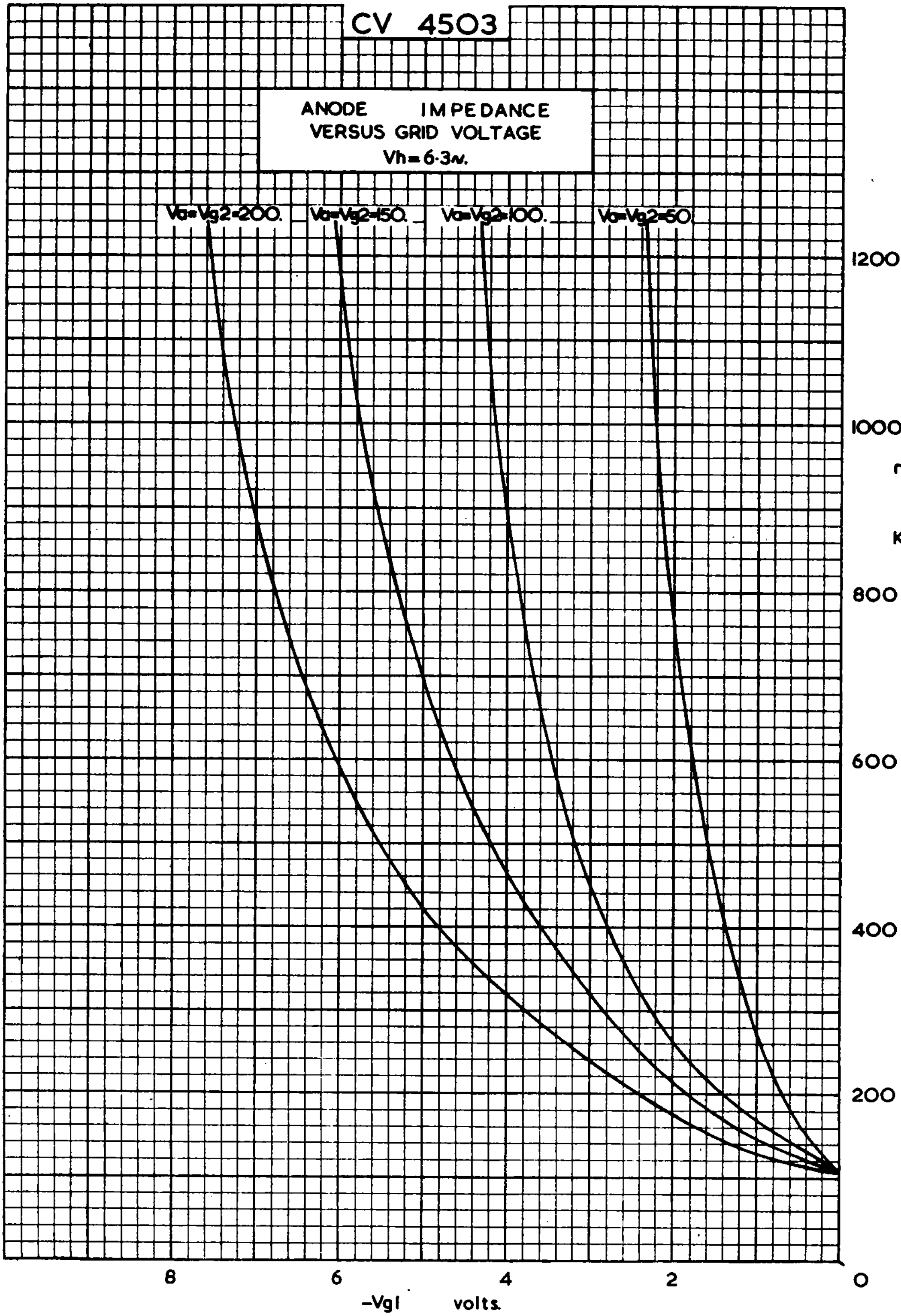
Lot Size of between 1301 and 3200
Inspection Level II (Code Letter L, Sample size 150)
An AQL of 0.4% (Accept on 2, reject on 3).

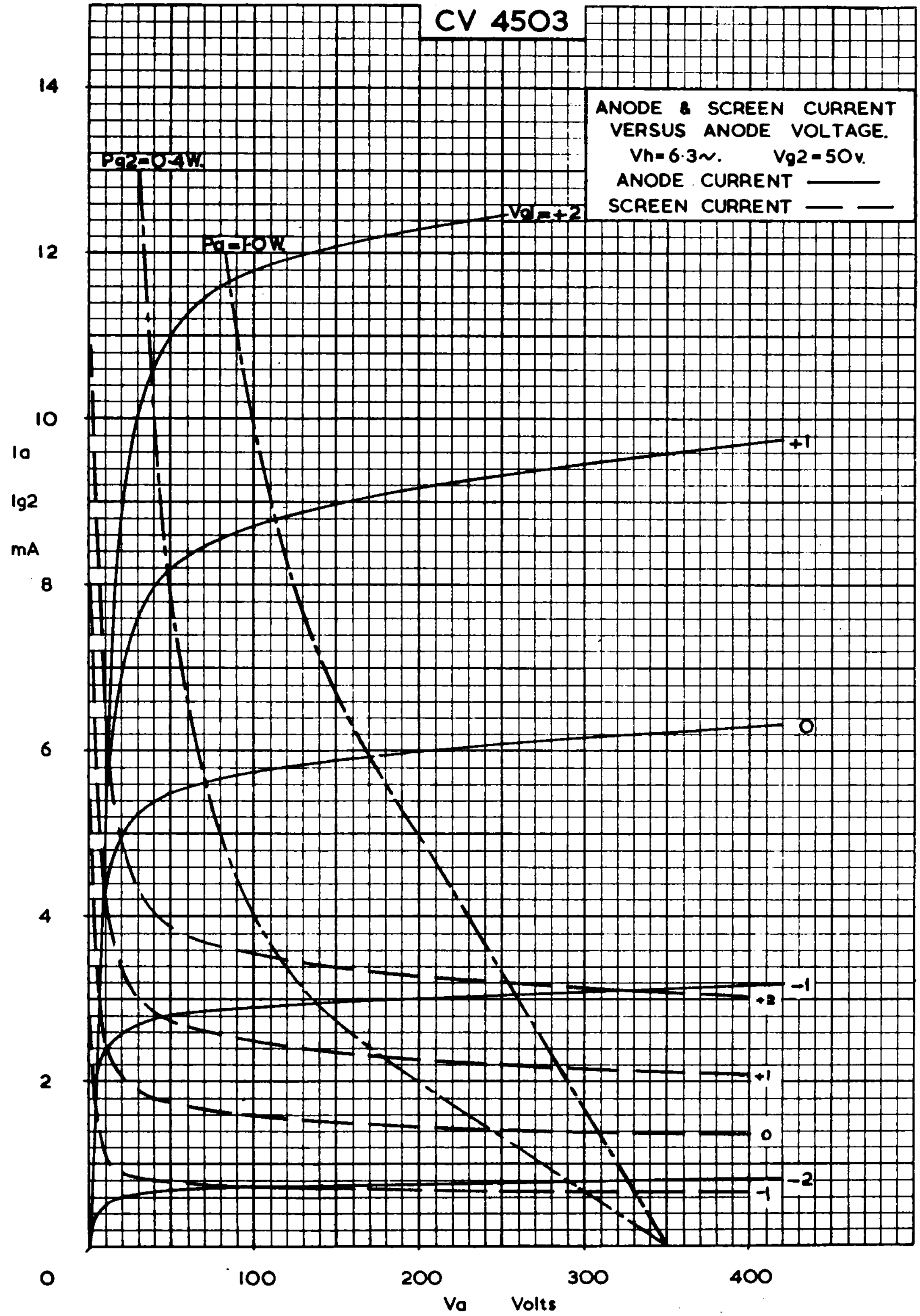


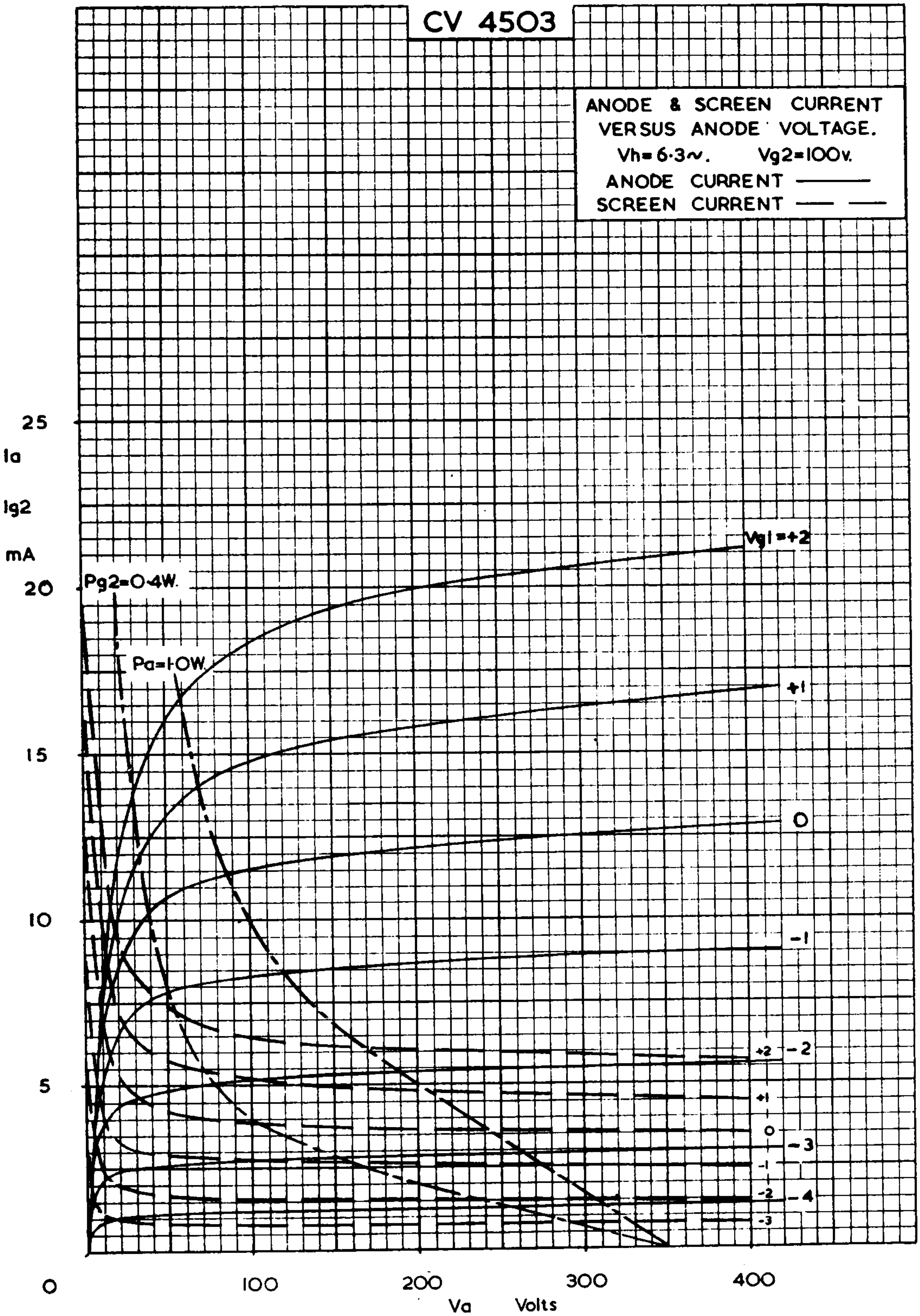


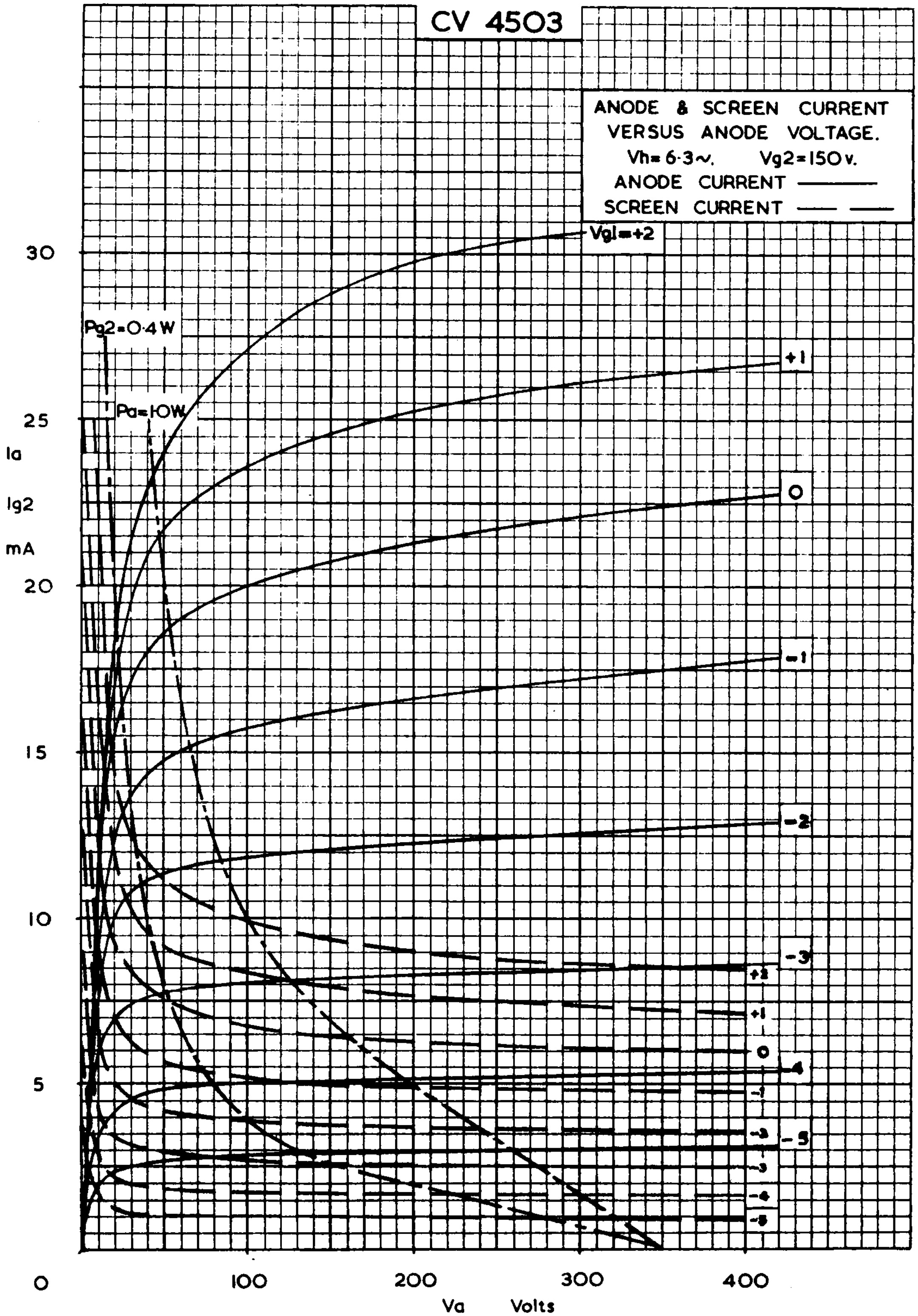
LIMITING DISTRIBUTIONS OF MAJOR CHARACTERISTICS

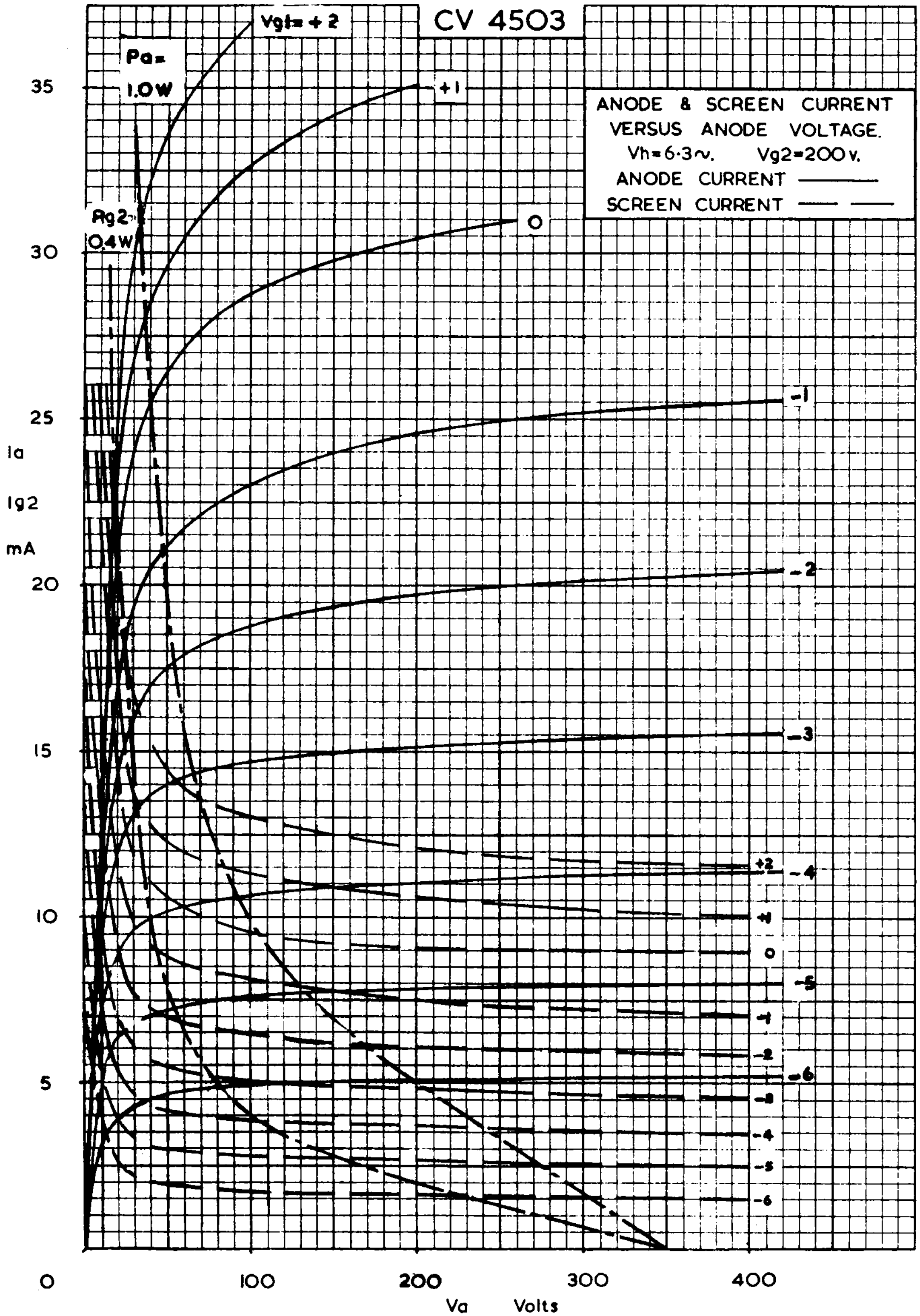

CV 4503
MUTUAL CONDUCTANCE
VERSUS GRID VOLTAGE.
Vh = 6·3 ~.
Va=Vg2=200v.
Va=Vg2=150v.
Va=Vg2=100v.
Va=Vg2=50v.
6·0
5·0
4·0
3·0
2·0
1·0
gm
mA/V
10
8
6
4
2
0
-Vg1 Volts

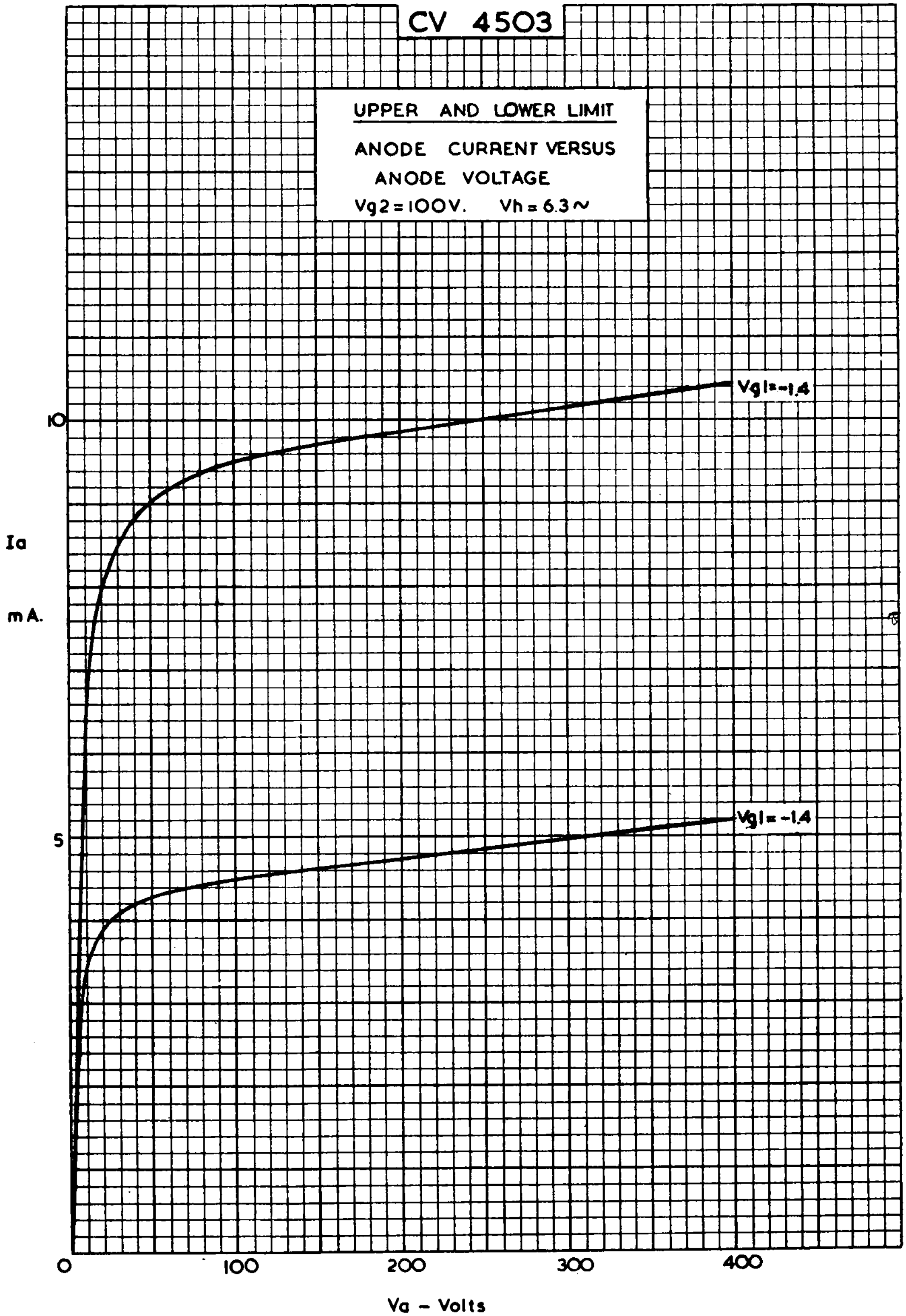

CV 4503
ANODE IMPEDANCE
VERSUS GRID VOLTAGE
Vh=6·3v.
Va=Vg2=200.
Va=Vg2=150.
Va=Vg2=100.
Va=Vg2=50
1200
1000
ra
KΩ
800
600
400
200
0
8
6
4
2
-Vg1 volts.

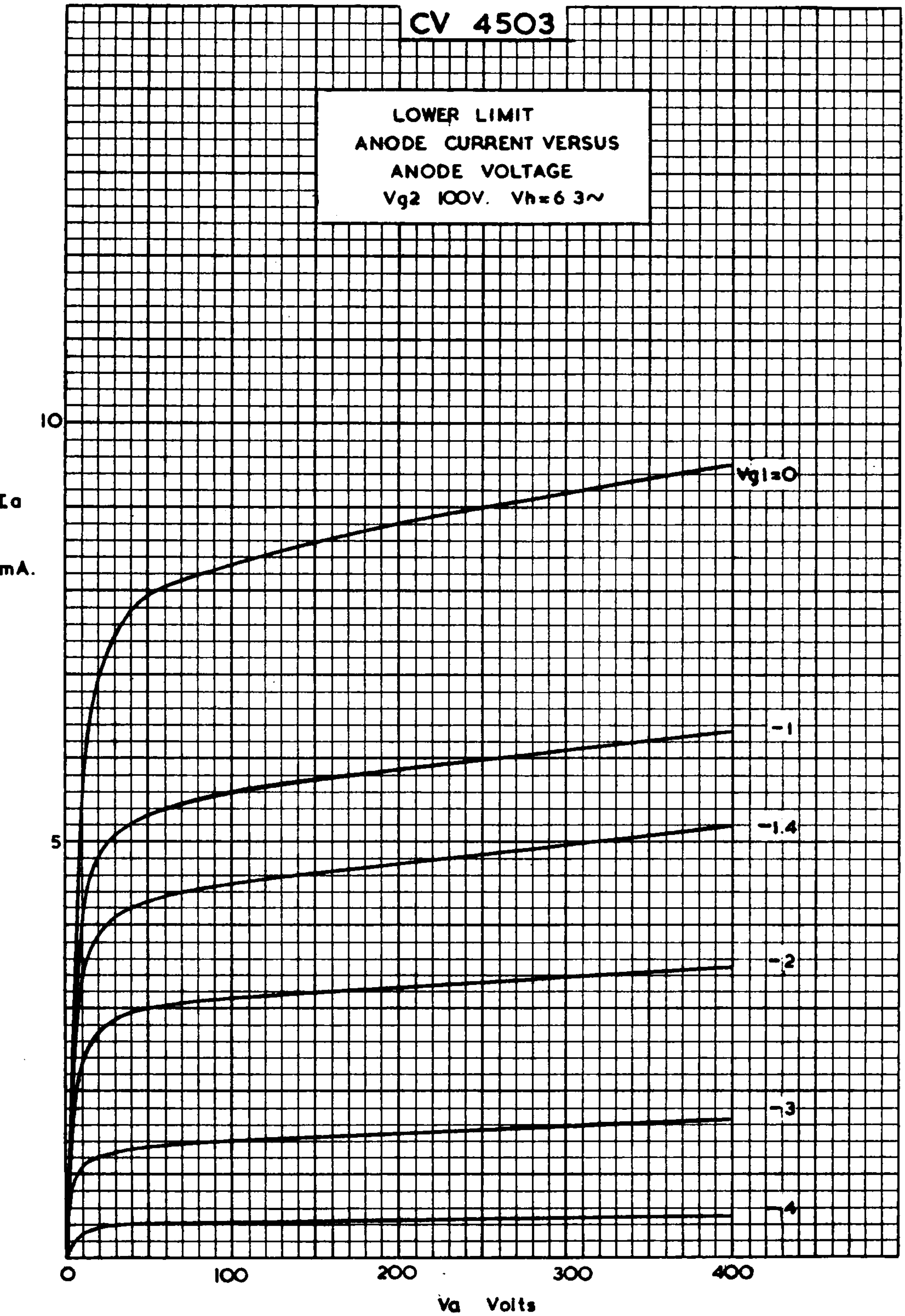

CV 4503
ANODE & SCREEN CURRENT VERSUS ANODE VOLTAGE.
Vh=6·3~. Vg2=50v.
ANODE CURRENT
SCREEN CURRENT
Pg2=0·4W.
Pa=1·0W.
Vg=+2
+1
0
-1
+2
+1
0
-2
-1
14
12
10
8
6
4
2
0
Ia
Ig2
mA
100
200
300
400
Va Volts

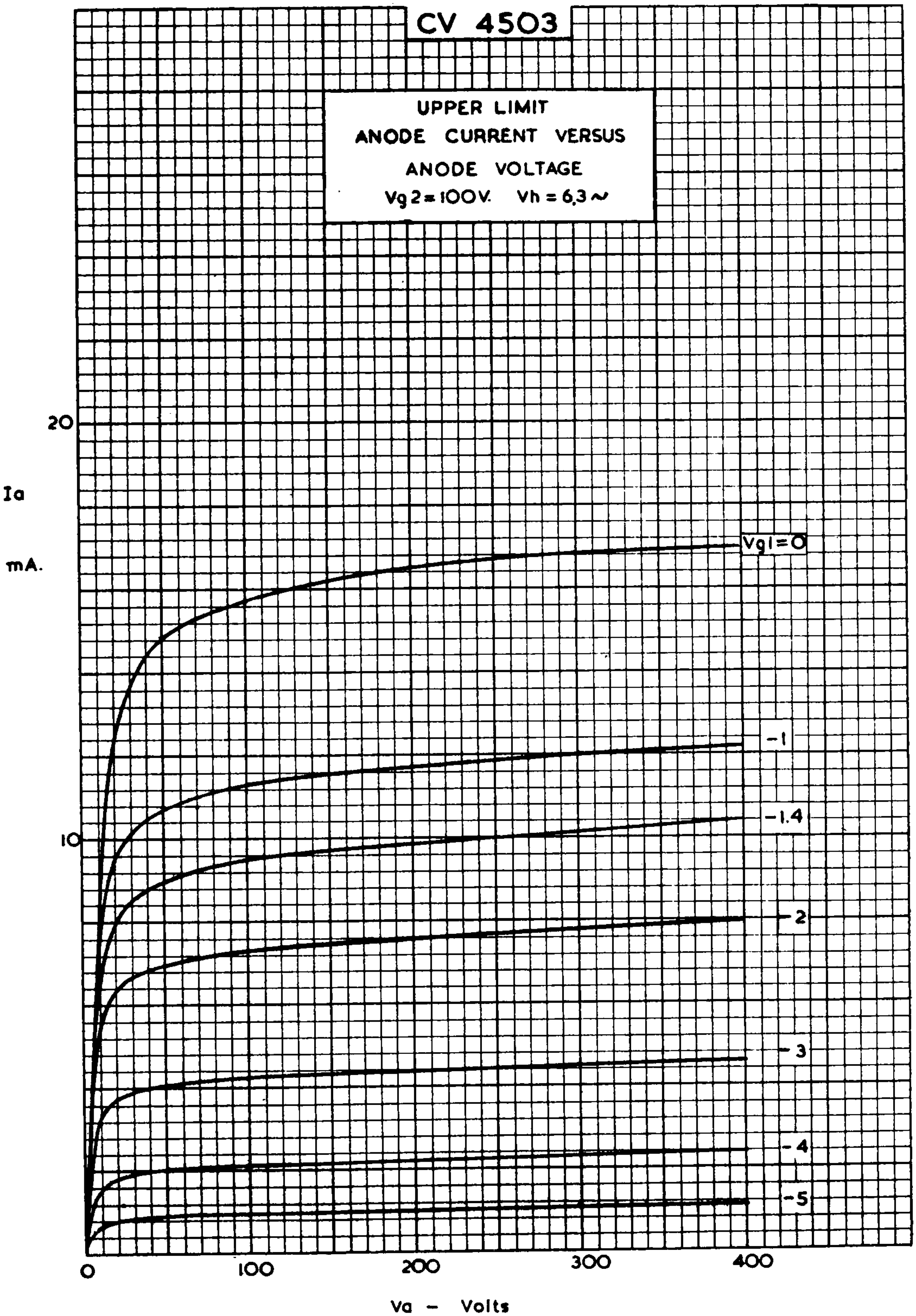

CV 4503
ANODE & SCREEN CURRENT
VERSUS ANODE VOLTAGE.
Vh=6·3∿. Vg2=100v.
ANODE CURRENT
SCREEN CURRENT
25
Ia
Ig2
mA
20
15
10
5
0
100
200
300
400
Va Volts
Pg2=0·4W.
Pa=1·0W.
Vg1=+2
+1
0
-1
-2
-3
-4
+2
+1
0
-1
-2
-3

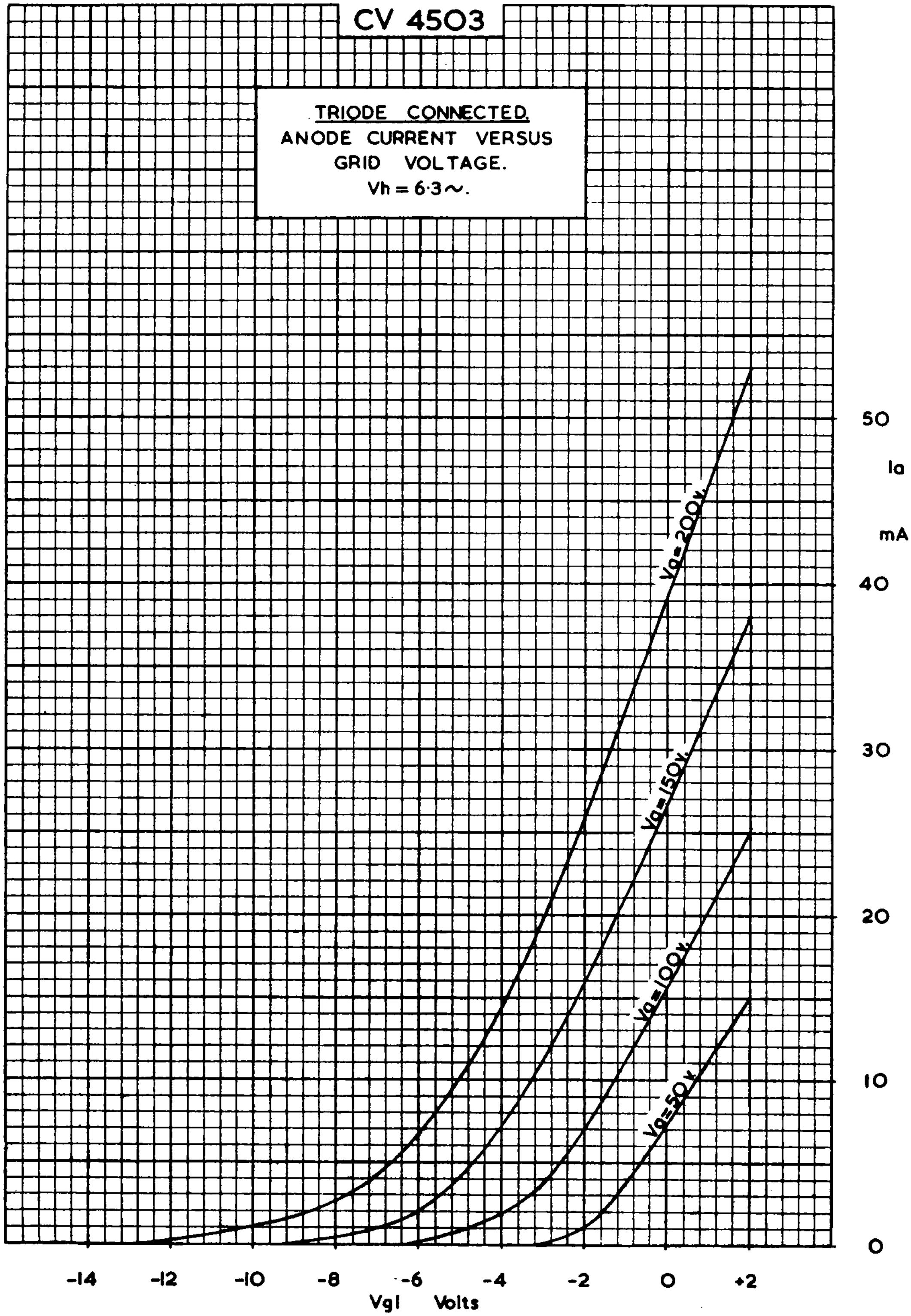

CV 4503
ANODE & SCREEN CURRENT
VERSUS ANODE VOLTAGE.
Vh= 6·3~. Vg2=150 v.
ANODE CURRENT
SCREEN CURRENT
Vg1=+2
+1
0
-1
-2
-3
-4
-5
Pg2=0·4 W
Pa=10W
Ia
Ig2
mA
30
25
20
15
10
5
0
100
200
300
400
Va Volts

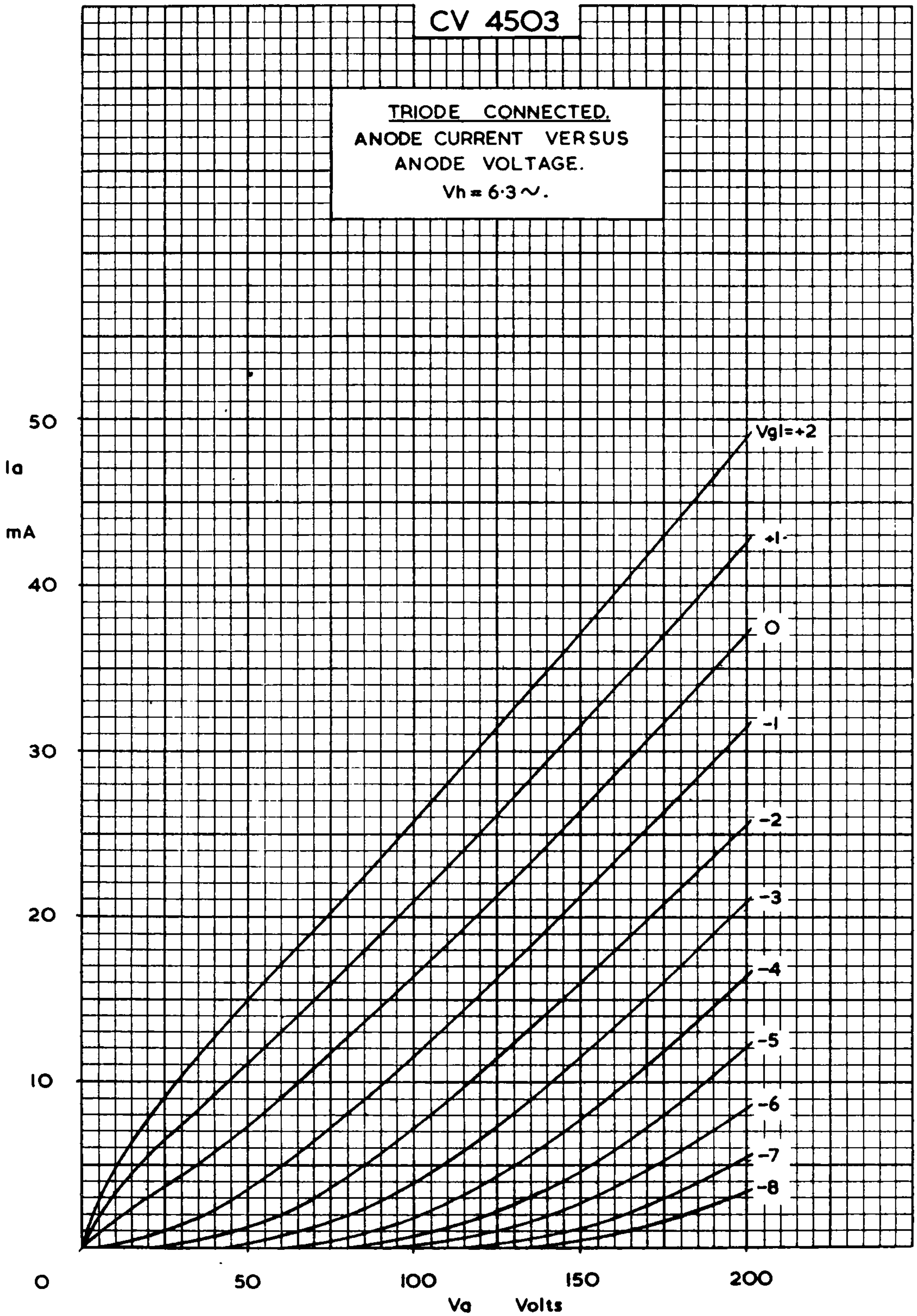

CV 4503
ANODE & SCREEN CURRENT
VERSUS ANODE VOLTAGE.
Vh=6·3~v. Vg2=200 v.
ANODE CURRENT
SCREEN CURRENT
Vg1= +2
+1
0
-1
-2
-3
-4
-5
-6
+2
+1
0
-1
-2
-3
-4
-5
-6
Pa= 1.0W
Pg2= 0.4W
35
30
25
20
15
10
5
0
Ia
Ig2
mA
100
200
300
400
Va Volts

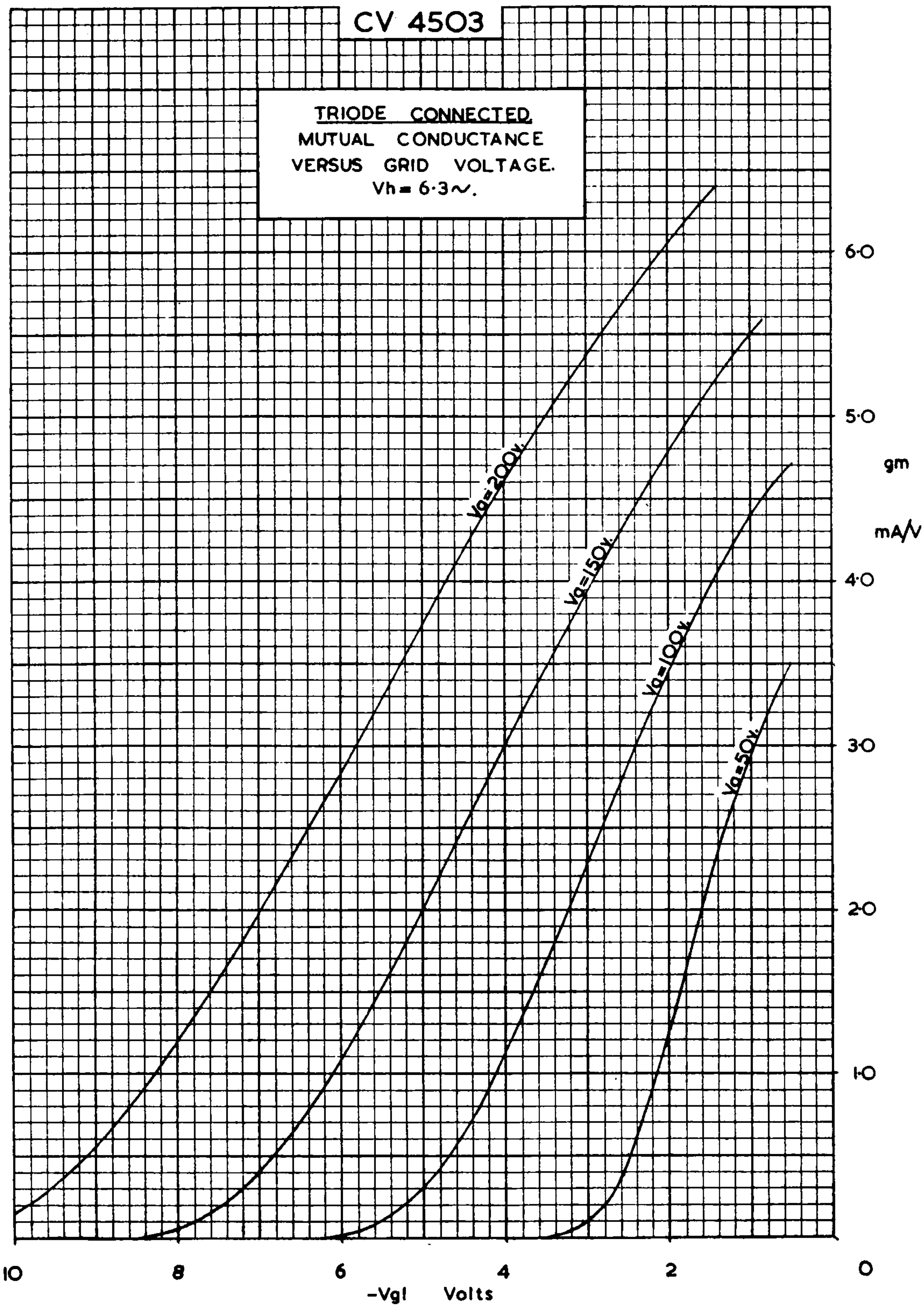

CV 4503
UPPER AND LOWER LIMIT
ANODE CURRENT VERSUS
ANODE VOLTAGE
Vg2 = 100V. Vh = 6.3 ~
Vg1 = -1.4
Vg1 = -1.4
Ia
mA.
10
5
0
100
200
300
400
Va - Volts

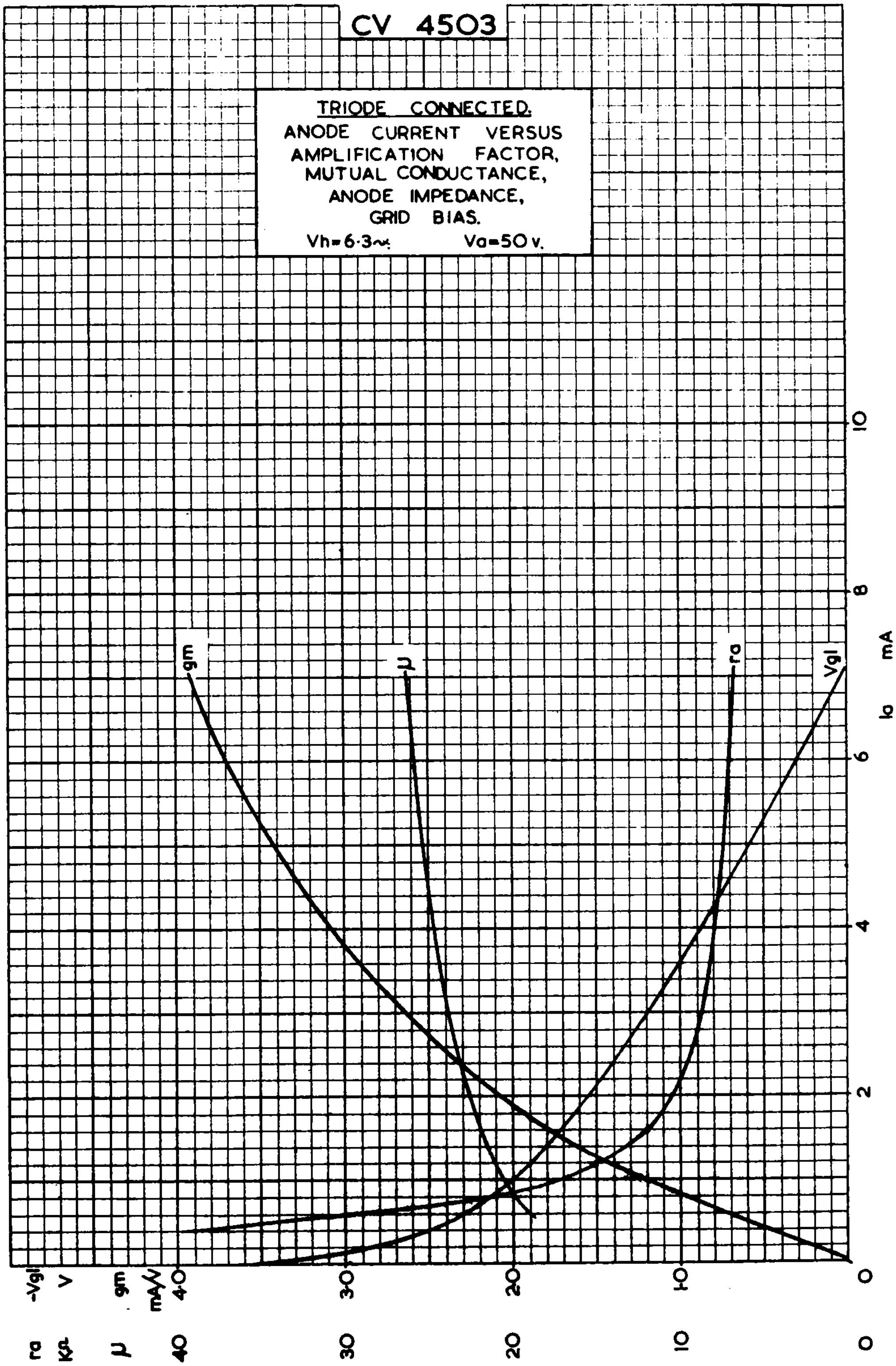

CV 4503
LOWER LIMIT
ANODE CURRENT VERSUS
ANODE VOLTAGE
Vg2 100V. Vh=6 3~
Ia
mA.
10
5
Vg1=0
-1
-1.4
-2
-3
-4
0
100
200
300
400
Va Volts

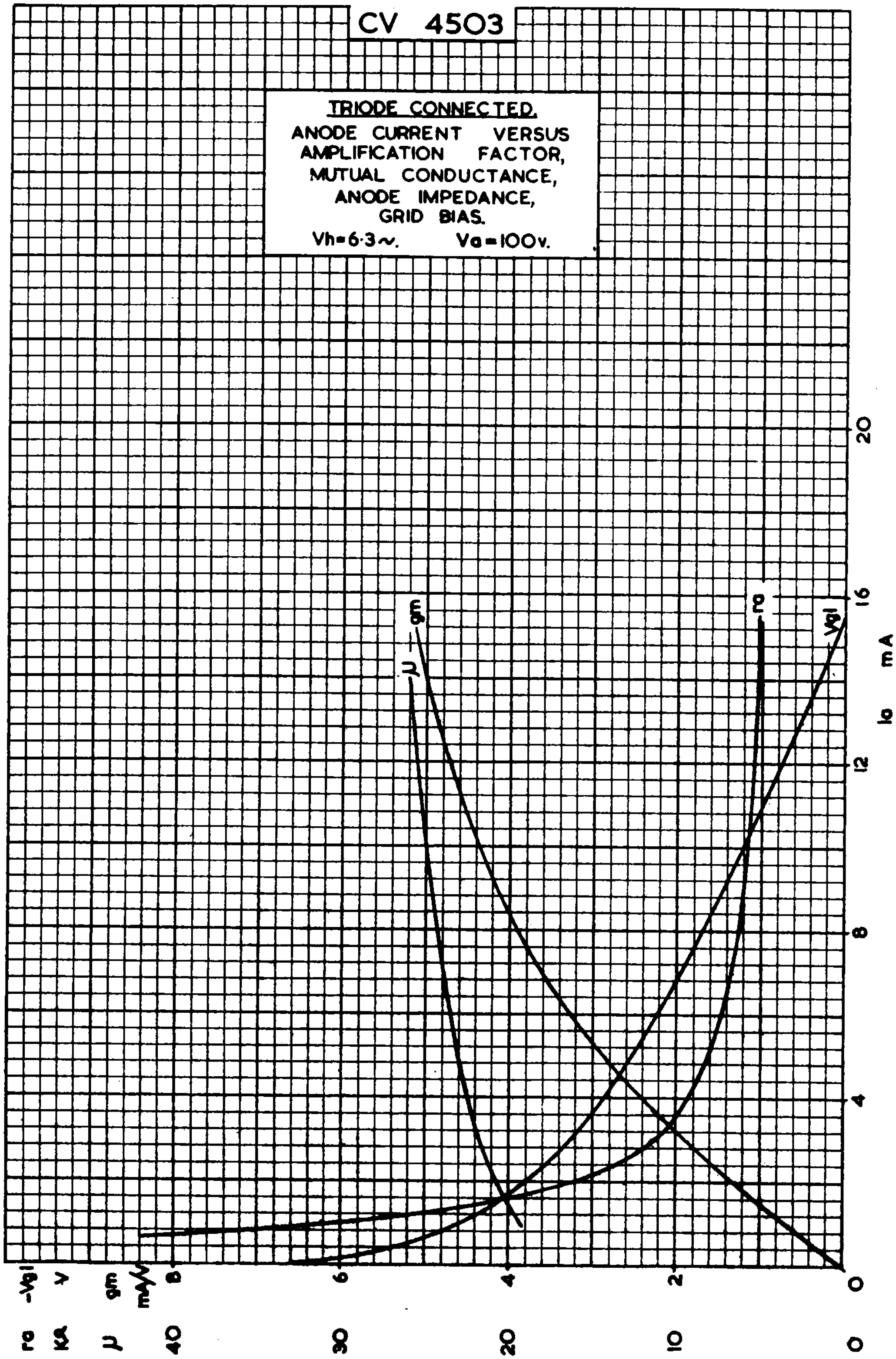

CV 4503
UPPER LIMIT
ANODE CURRENT VERSUS
ANODE VOLTAGE
Vg 2 = 100V. Vh = 6,3 ~
20
Ia
mA.
10
Vg1 = 0
-1
-1.4
-2
-3
-4
-5
0
100
200
300
400
Va - Volts

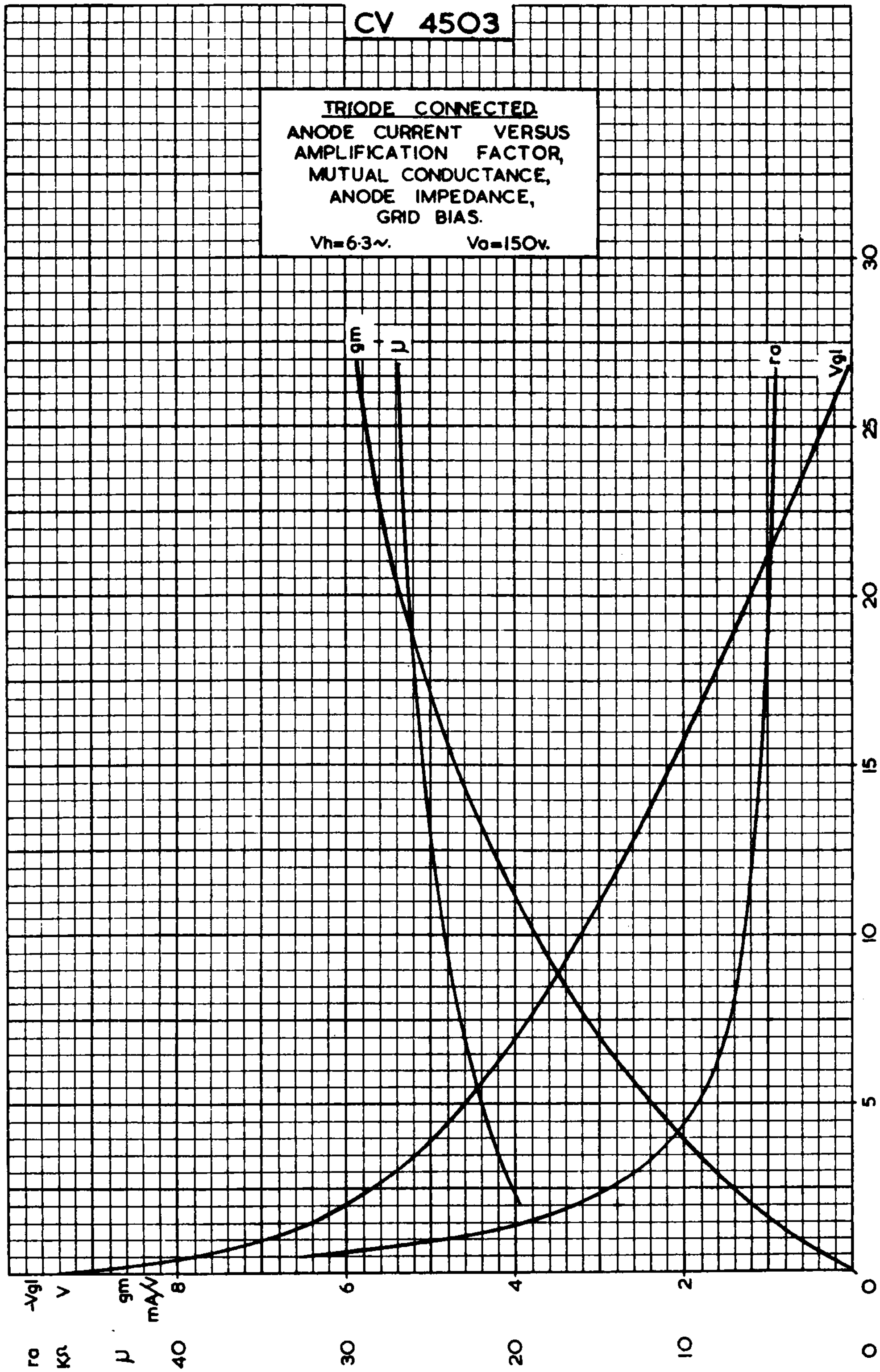

CV 4503
TRIODE CONNECTED.
ANODE CURRENT VERSUS
GRID VOLTAGE.
Vh = 6·3 ~.
Va=200V.
Va=150V.
Va=100V.
Va=50V.
50
Ia
mA
40
30
20
10
0
-14
-12
-10
-8
-6
-4
-2
0
+2
Vg1 Volts

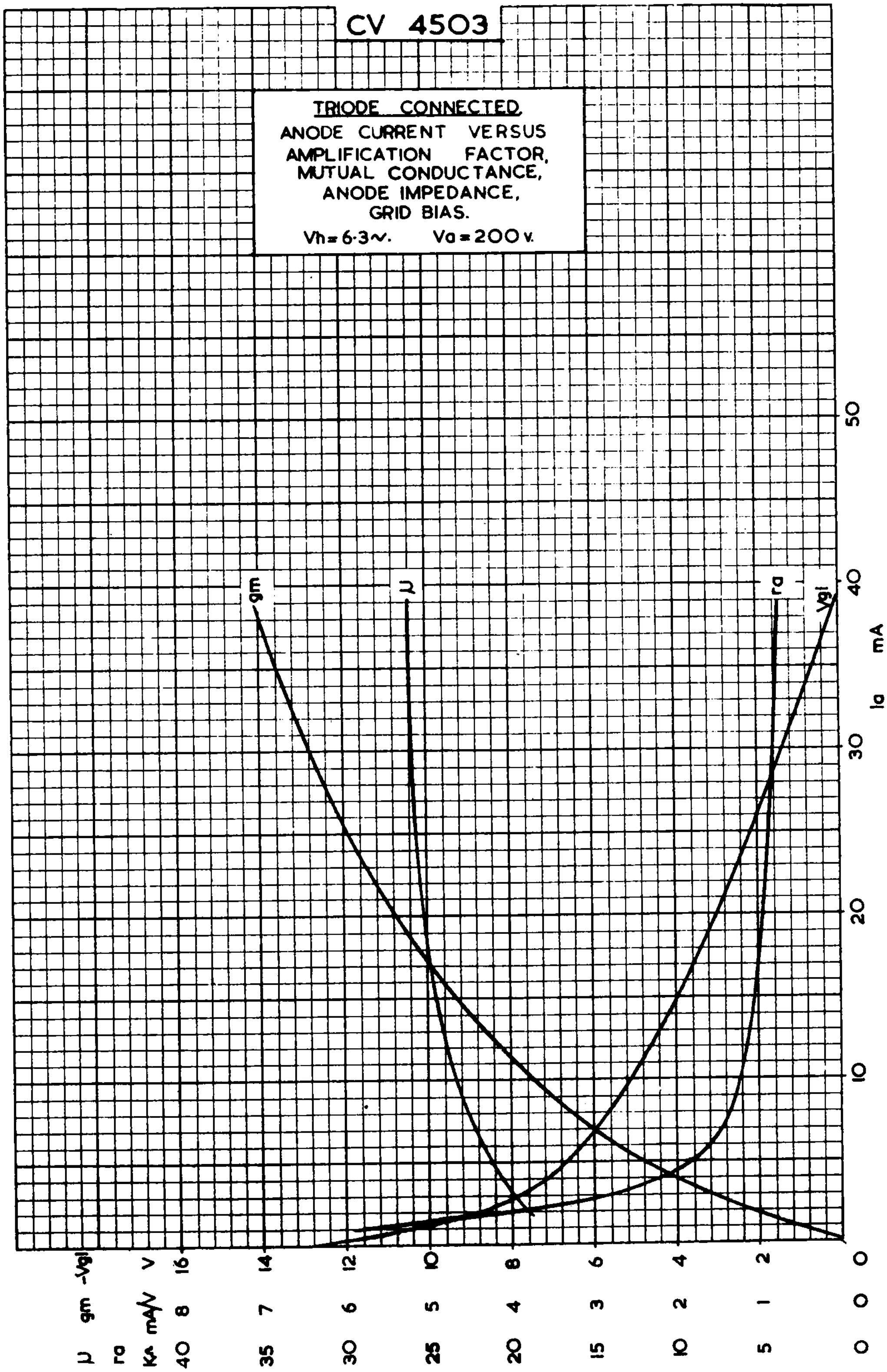

CV 4503
TRIODE CONNECTED.
ANODE CURRENT VERSUS
ANODE VOLTAGE.
Vh = 6·3 ~.
50
Ia
mA
40
30
20
10
0
50
100
150
200
Va Volts
Vgl=+2
+1
0
-1
-2
-3
-4
-5
-6
-7
-8

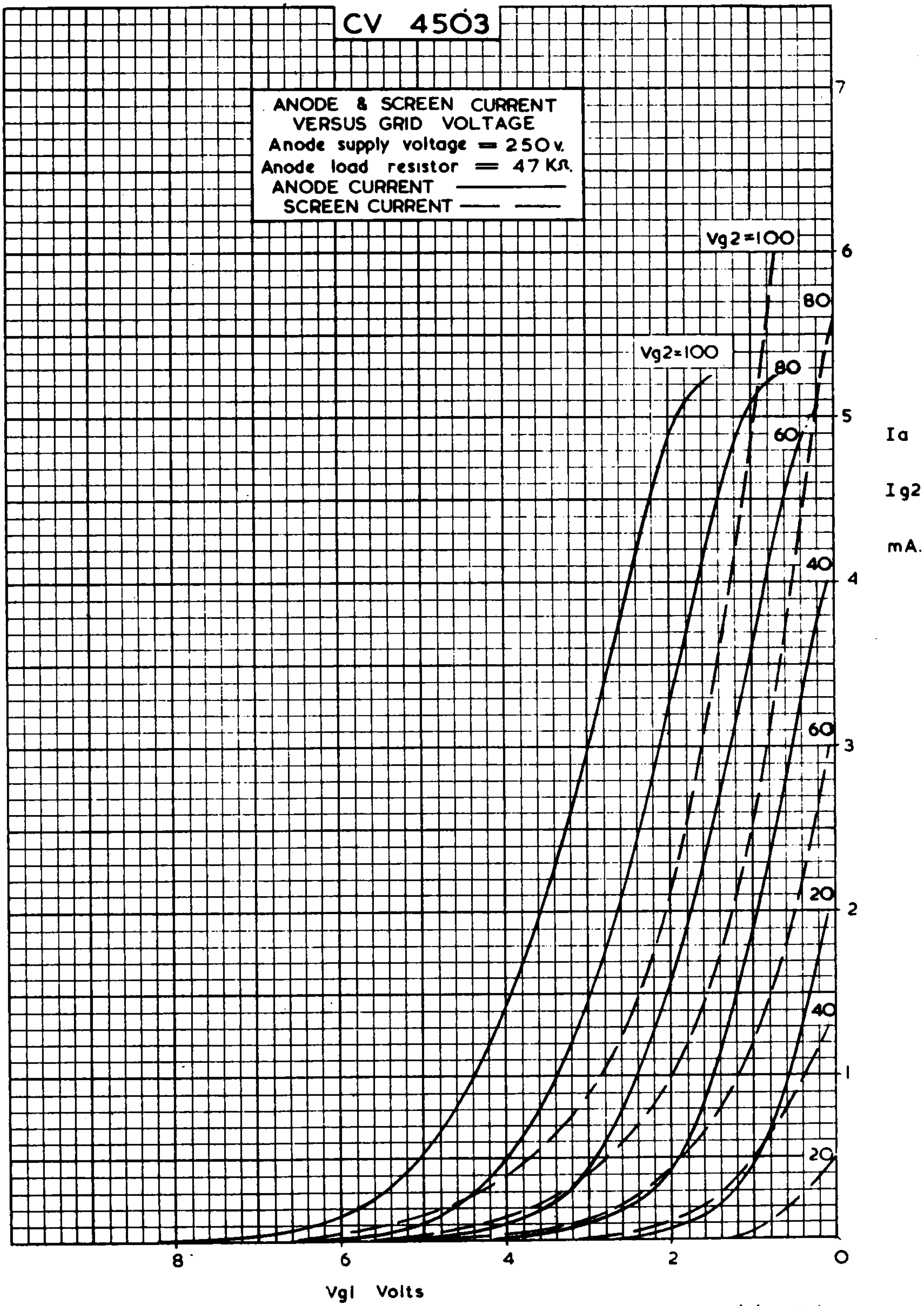

CV 4503
TRIODE CONNECTED
MUTUAL CONDUCTANCE
VERSUS GRID VOLTAGE.
Vh = 6·3∼.
Va=200V.
Va=150V.
Va=100V.
Va=50V.
6·0
5·0
4·0
3·0
2·0
1·0
gm
mA/V
10
8
6
4
2
0
-Vg1 Volts

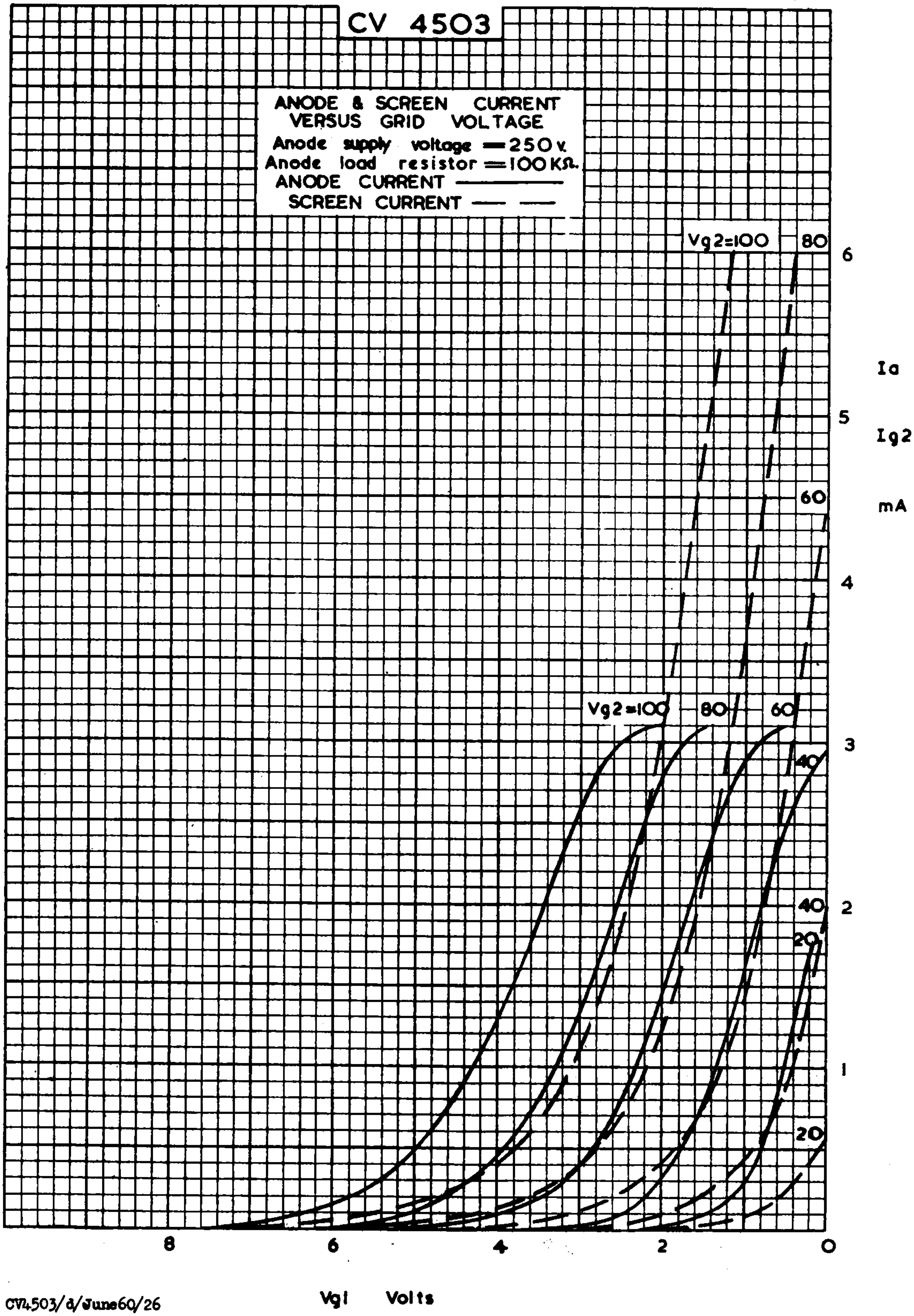

CV 4503
TRIODE CONNECTED.
ANODE CURRENT VERSUS AMPLIFICATION FACTOR, MUTUAL CONDUCTANCE, ANODE IMPEDANCE, GRID BIAS.
Vh=6·3~ Va=50 v.
gm
μ
ra
Vgl
Ia mA
10
8
6
4
2
0
-Vgl V
gm mA/V
4·0
3·0
2·0
1·0
0
ra kΩ
μ
40
30
20
10
0


CV 4503
TRIODE CONNECTED.
ANODE CURRENT VERSUS
AMPLIFICATION FACTOR,
MUTUAL CONDUCTANCE,
ANODE IMPEDANCE,
GRID BIAS.
Vh=6·3~. Va=100v.
Ia mA
20
16
12
8
4
0
μ
gm
ra
Vg1
-Vg1 V
gm mA/V
ra kΩ
μ
8
6
4
2
0
40
30
20
10
0

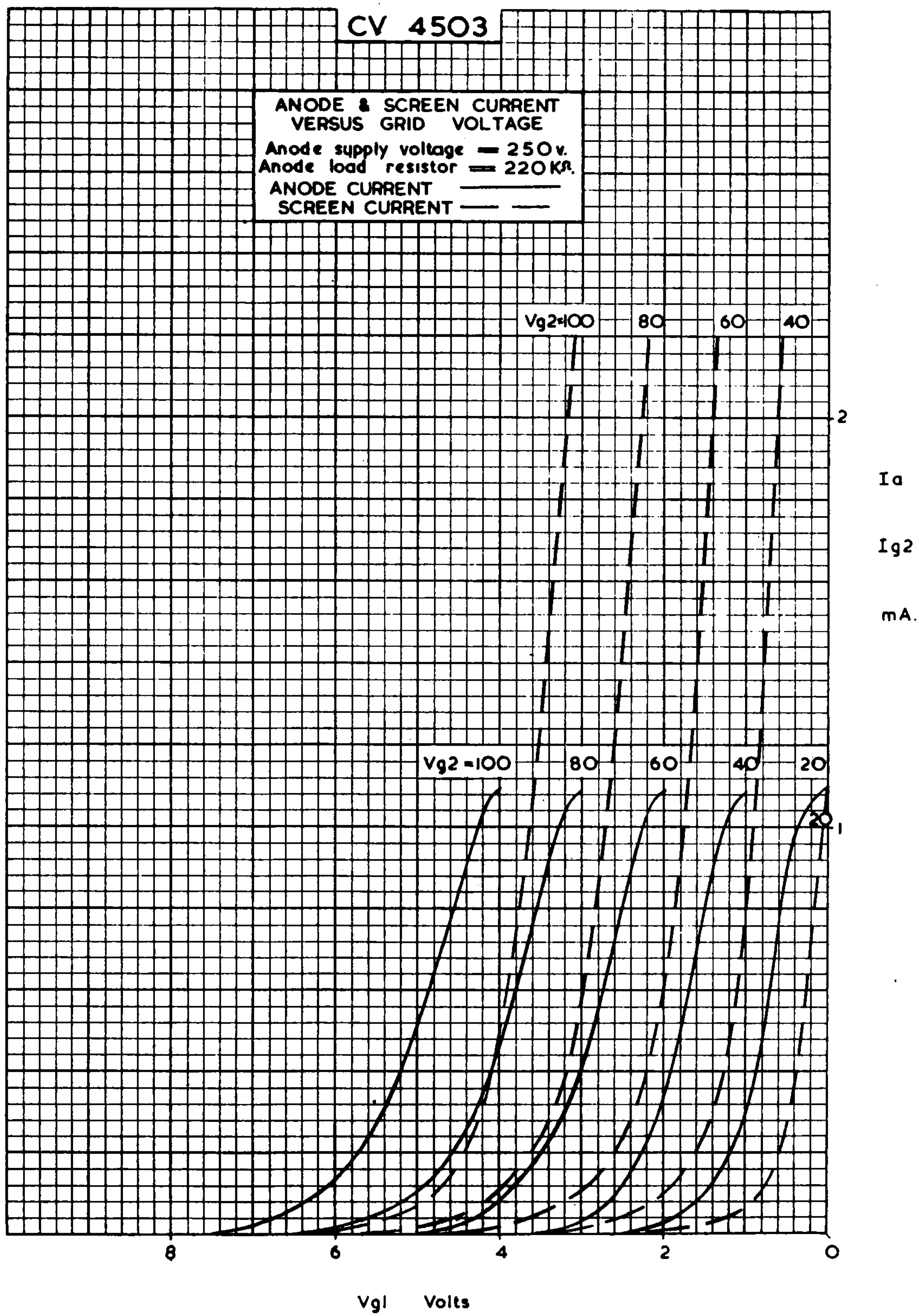

CV 4503
TRIODE CONNECTED
ANODE CURRENT VERSUS
AMPLIFICATION FACTOR,
MUTUAL CONDUCTANCE,
ANODE IMPEDANCE,
GRID BIAS.
Vh=6·3~.
Va=150v.
gm
μ
ra
Vgl
Ia mA
0
5
10
15
20
25
30
-Vgl V
gm mA/V
8
6
4
2
0
ra KΩ
μ
40
30
20
10
0

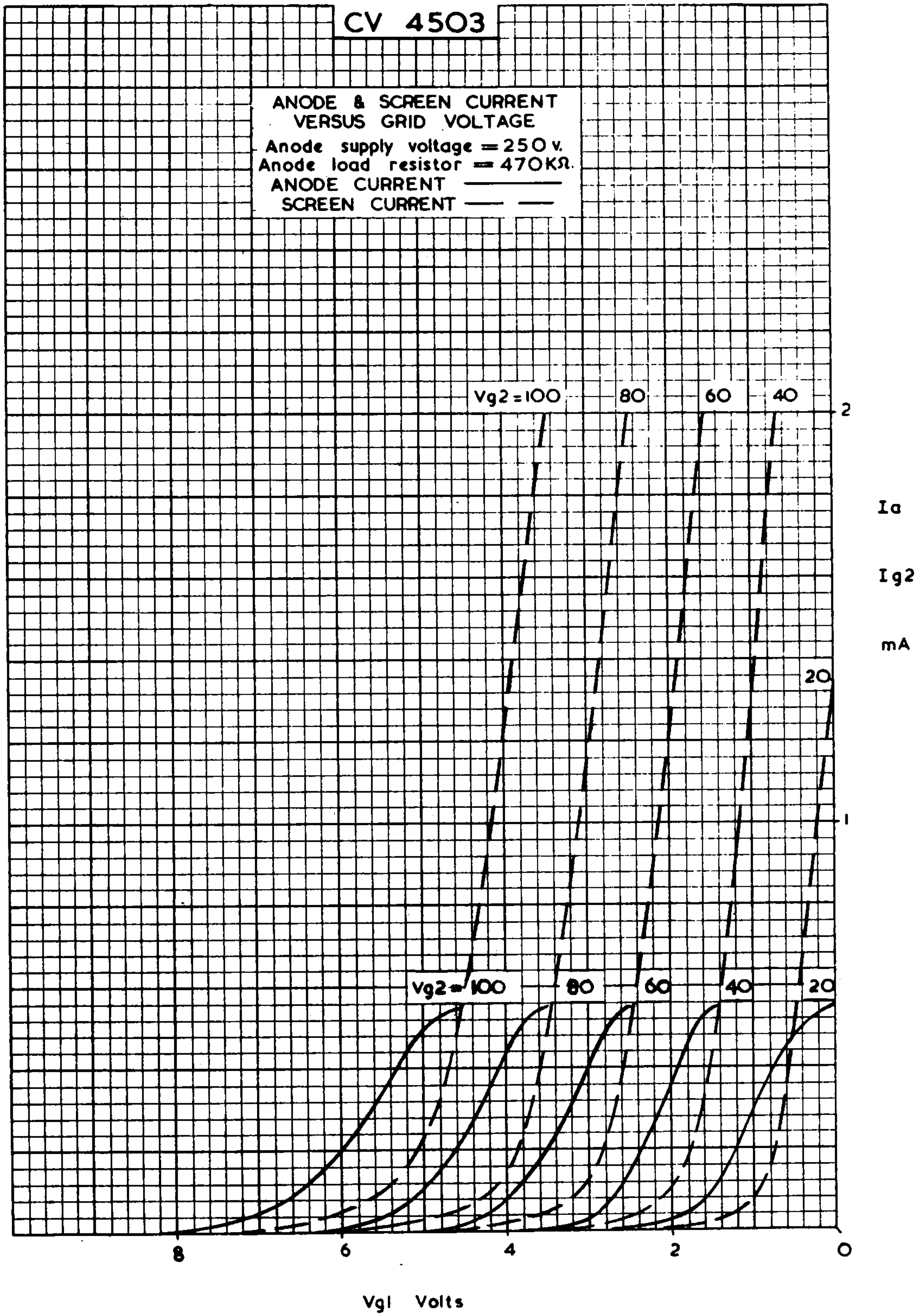

CV 4503
TRIODE CONNECTED
ANODE CURRENT VERSUS
AMPLIFICATION FACTOR,
MUTUAL CONDUCTANCE,
ANODE IMPEDANCE,
GRID BIAS.
Vh = 6·3∼. Va = 200 v.
gm
μ
ra
Vgl
Ia mA
10
20
30
40
50
-Vgl V 16 14 12 10 8 6 4 2 0
gm mA/V 8 7 6 5 4 3 2 1 0
μ ra KΩ 40 35 30 25 20 15 10 5 0

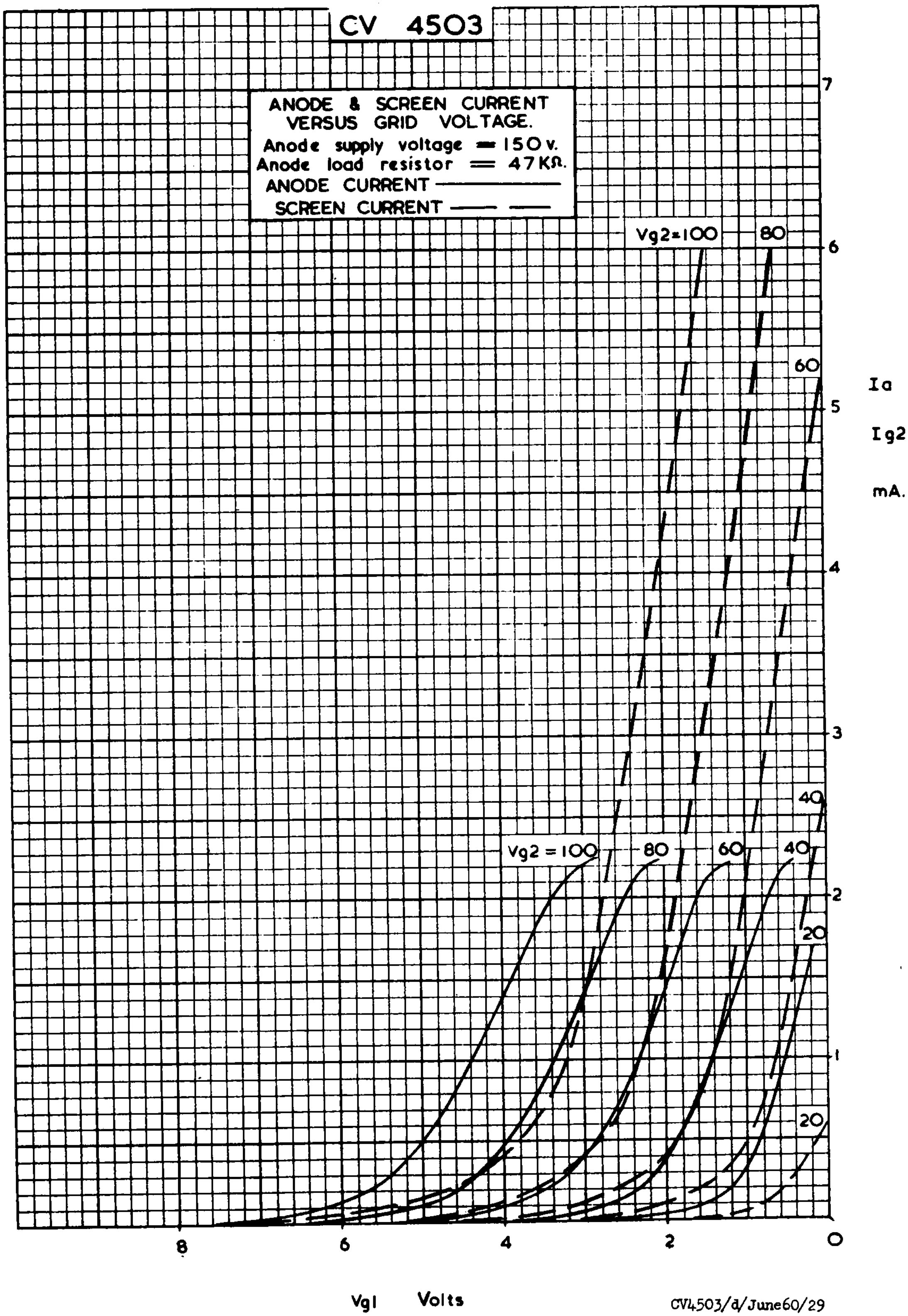

CV 4503
ANODE & SCREEN CURRENT
VERSUS GRID VOLTAGE
Anode supply voltage = 250 v.
Anode load resistor = 47 KΩ.
ANODE CURRENT ————
SCREEN CURRENT — —
Vg2=100
80
60
40
20
Vg2=100
80
60
40
20
7
6
5
4
3
2
1
0
8
6
4
2
Ia
Ig2
mA.
Vg1 Volts

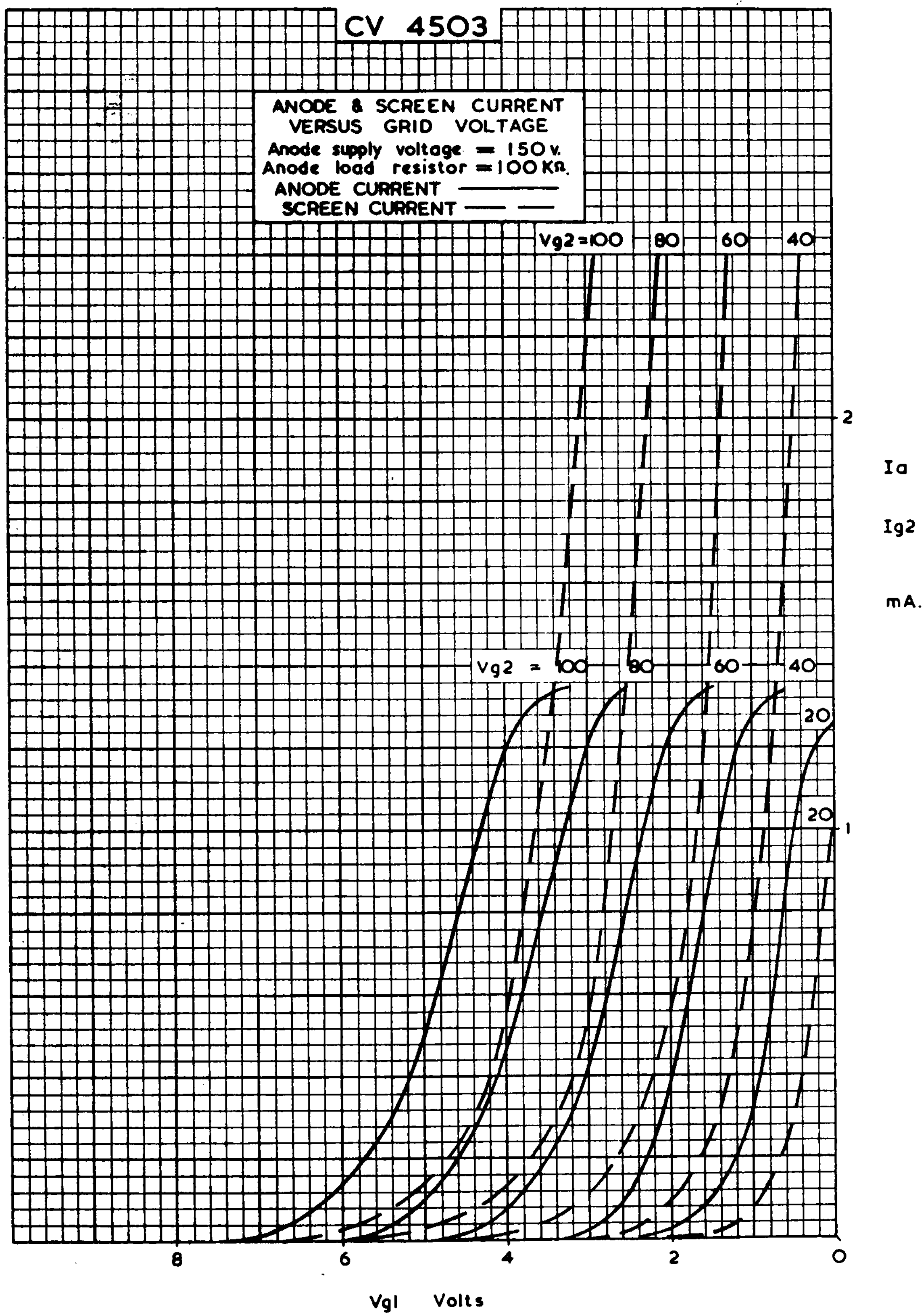

CV 4503
ANODE & SCREEN CURRENT
VERSUS GRID VOLTAGE
Anode supply voltage = 250 v.
Anode load resistor = 100 KΩ.
ANODE CURRENT
SCREEN CURRENT
Vg2=100
80
60
40
20
Vg2=100
80
60
40
20
6
5
4
3
2
1
8
6
4
2
0
Ia
Ig2
mA
Vg1 Volts

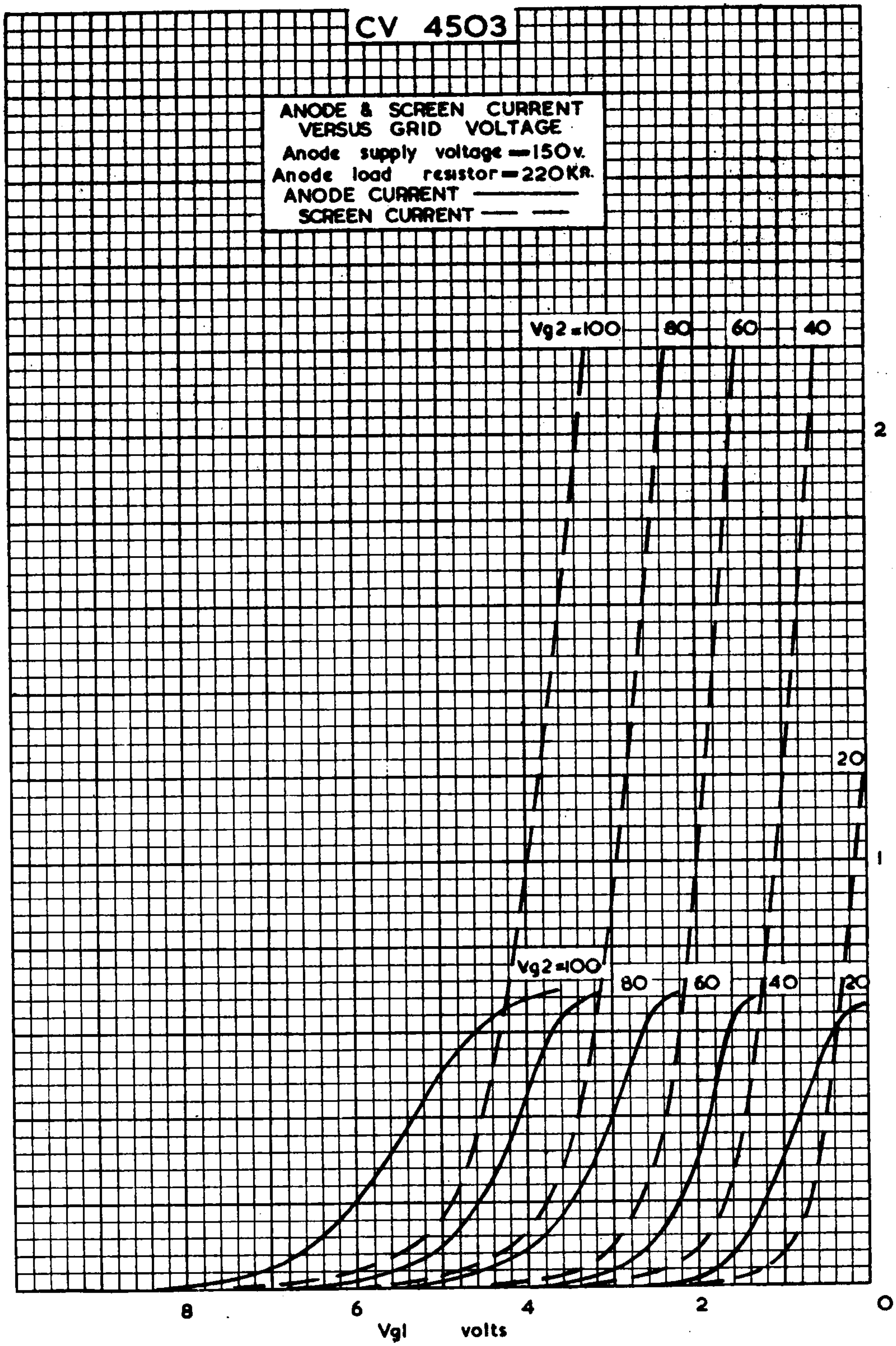
CV 4503

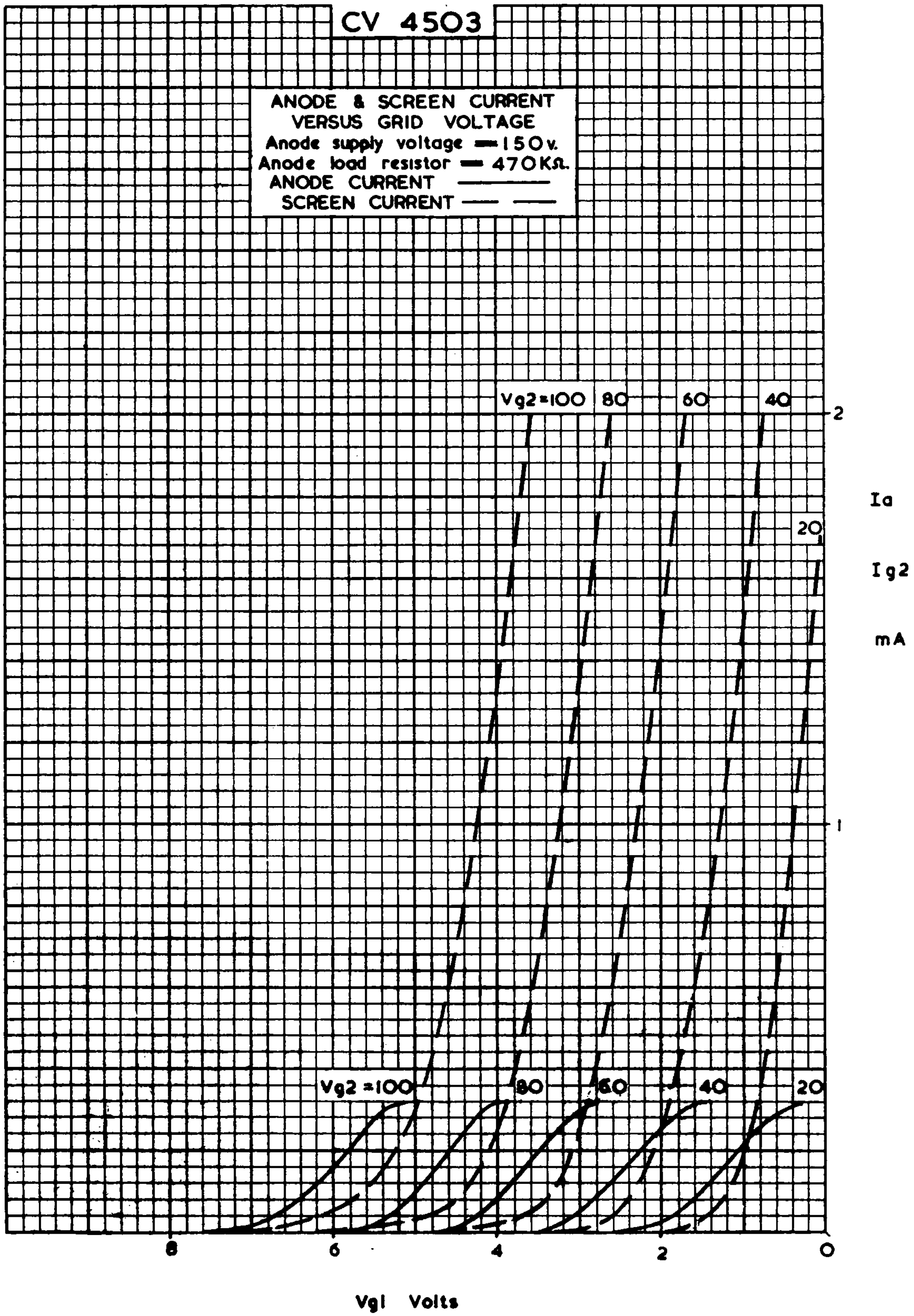

CV 4503
ANODE & SCREEN CURRENT
VERSUS GRID VOLTAGE
Anode supply voltage = 250v.
Anode load resistor = 220KΩ.
ANODE CURRENT
SCREEN CURRENT
Vg2=100
80
60
40
Vg2 =100
80
60
40
20
20
2
1
Ia
Ig2
mA.
8
6
4
2
0
Vg1 Volts

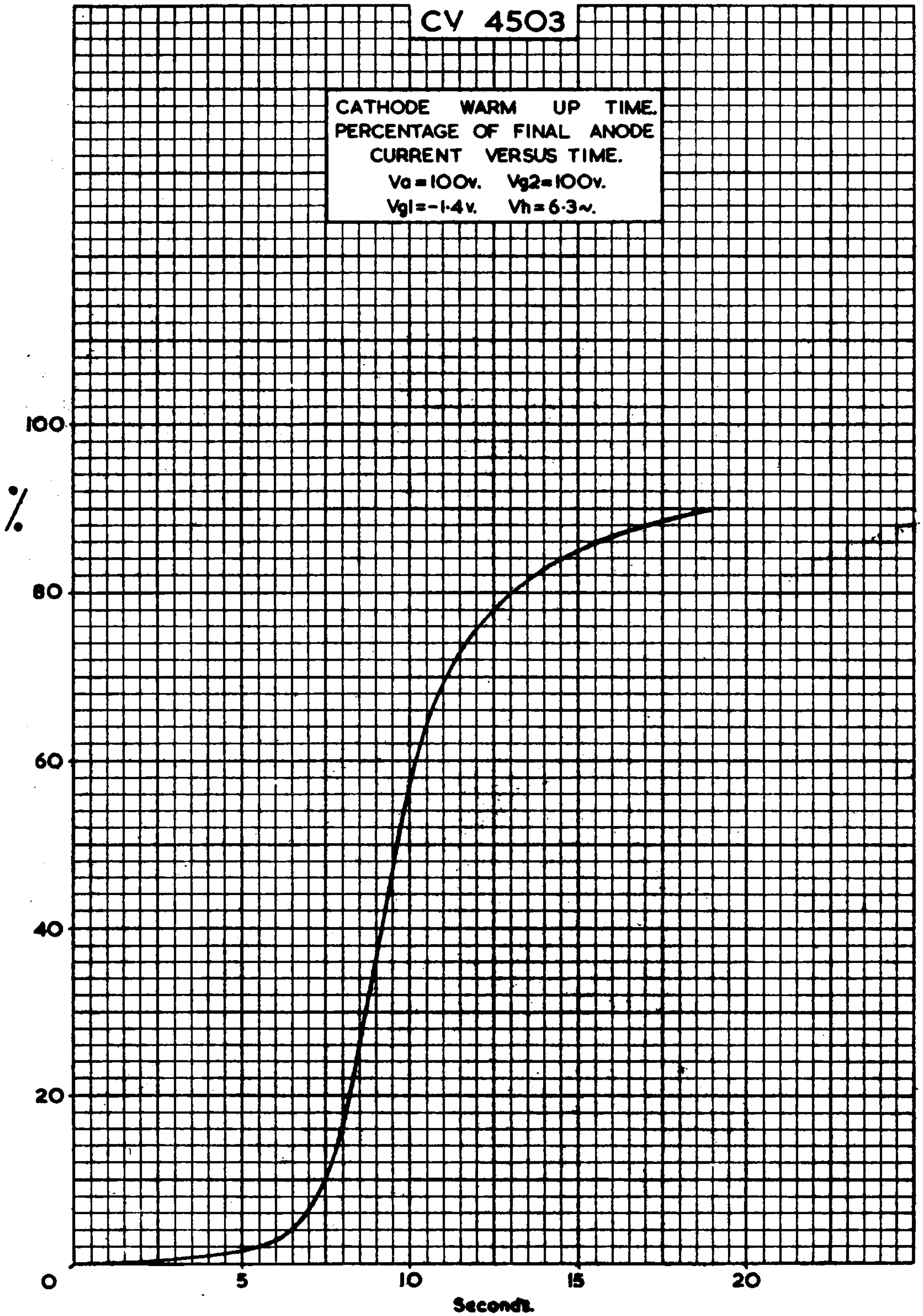

CV 4503
ANODE & SCREEN CURRENT
VERSUS GRID VOLTAGE
Anode supply voltage = 250 v.
Anode load resistor = 470KΩ.
ANODE CURRENT
SCREEN CURRENT
Vg2 = 100
80
60
40
20
Vg2 = 100
80
60
40
20
2
1
Ia
Ig2
mA
8
6
4
2
0
Vg1 Volts

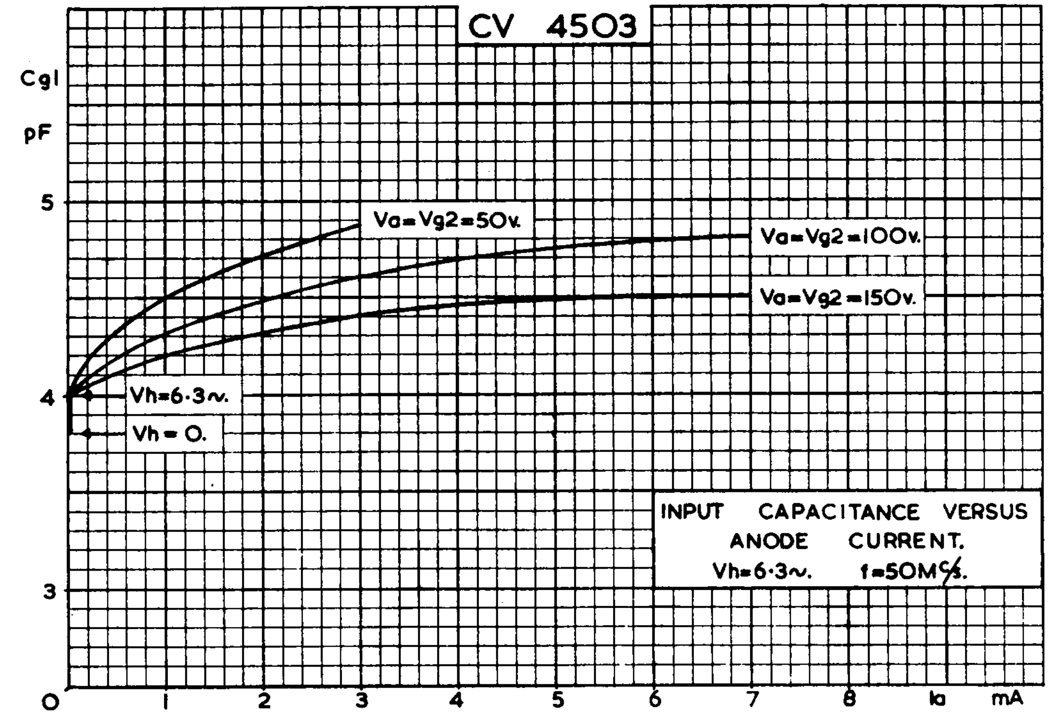

CV 4503
ANODE & SCREEN CURRENT
VERSUS GRID VOLTAGE.
Anode supply voltage = 150 v.
Anode load resistor = 47KΩ.
ANODE CURRENT
SCREEN CURRENT
Vg2=100
80
60
40
20
Vg2 = 100
80
60
40
20
7
6
5
4
3
2
1
0
8
6
4
2
Ia
Ig2
mA.
Vg1 Volts

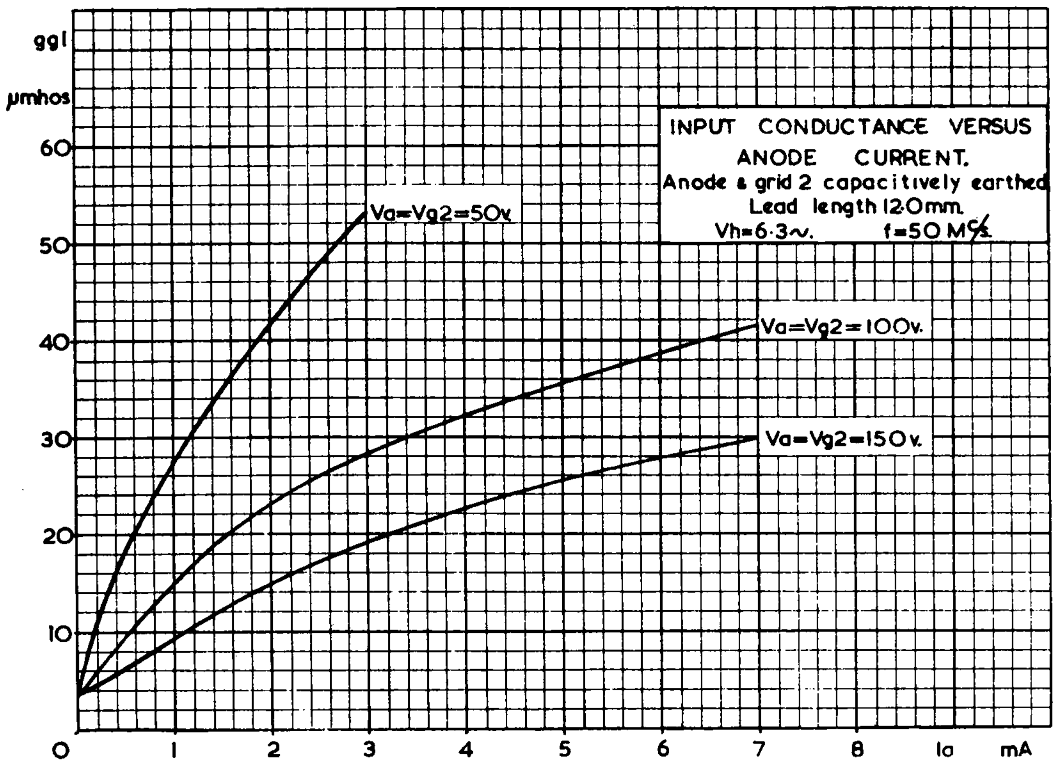

CV 4503
ANODE & SCREEN CURRENT
VERSUS GRID VOLTAGE
Anode supply voltage = 150 v.
Anode load resistor = 100 KΩ.
ANODE CURRENT
SCREEN CURRENT
Vg2 = 100
80
60
40
Vg2 = 100
80
60
40
20
20
2
1
Ia
Ig2
mA.
8
6
4
2
0
Vg1 Volts


CV 4503
ANODE & SCREEN CURRENT
VERSUS GRID VOLTAGE
Anode supply voltage = 150 v.
Anode load resistor = 220 KΩ.
ANODE CURRENT
SCREEN CURRENT
Vg2 = 100
80
60
40
20
Vg2 = 100
80
60
40
20
2
1
0
Ia
Ig2
mA
8
6
4
2
Vg1 volts


CV 4503
ANODE & SCREEN CURRENT
VERSUS GRID VOLTAGE
Anode supply voltage = 150v.
Anode load resistor = 470KΩ.
ANODE CURRENT
SCREEN CURRENT
Vg2=100
80
60
40
20
Vg2 =100
80
60
40
20
2
1
Ia
Ig2
mA
8
6
4
2
0
Vg1 Volts


CV 4503
CATHODE WARM UP TIME.
PERCENTAGE OF FINAL ANODE CURRENT VERSUS TIME.
Va=100v. Vg2=100v.
Vg1=-1·4v. Vh=6·3~.
100
%
80
60
40
20
0
5
10
15
20
Seconds.


CV 4503
Cgl
pF
5
4
3
0
Va=Vg2=50v.
Va=Vg2=100v.
Va=Vg2=150v.
Vh=6·3~.
Vh=0.
INPUT CAPACITANCE VERSUS
ANODE CURRENT.
Vh=6·3~. f=50Mc/s.
1
2
3
4
5
6
7
8
Ia mA


ggl
µmhos
60
50
40
30
20
10
0
INPUT CONDUCTANCE VERSUS
ANODE CURRENT.
Anode & grid 2 capacitively earthed
Lead length 12·0mm.
Vh=6·3~. f=50 Mc/s.
Va=Vg2=50v.
Va=Vg2=100v.
Va=Vg2=150v.
1
2
3
4
5
6
7
8
Ia mA

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:- $$R_k \text{ eff.} = R_k + \frac{R_a}{\mu}$$

For Pentodes:- $$R_k \text{ eff.} = \frac{I_k \times R_k}{I_a} + \frac{I_{g2} \times R_{g2}}{I_a \times \mu(g1 - g2)}$$

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.

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

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

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

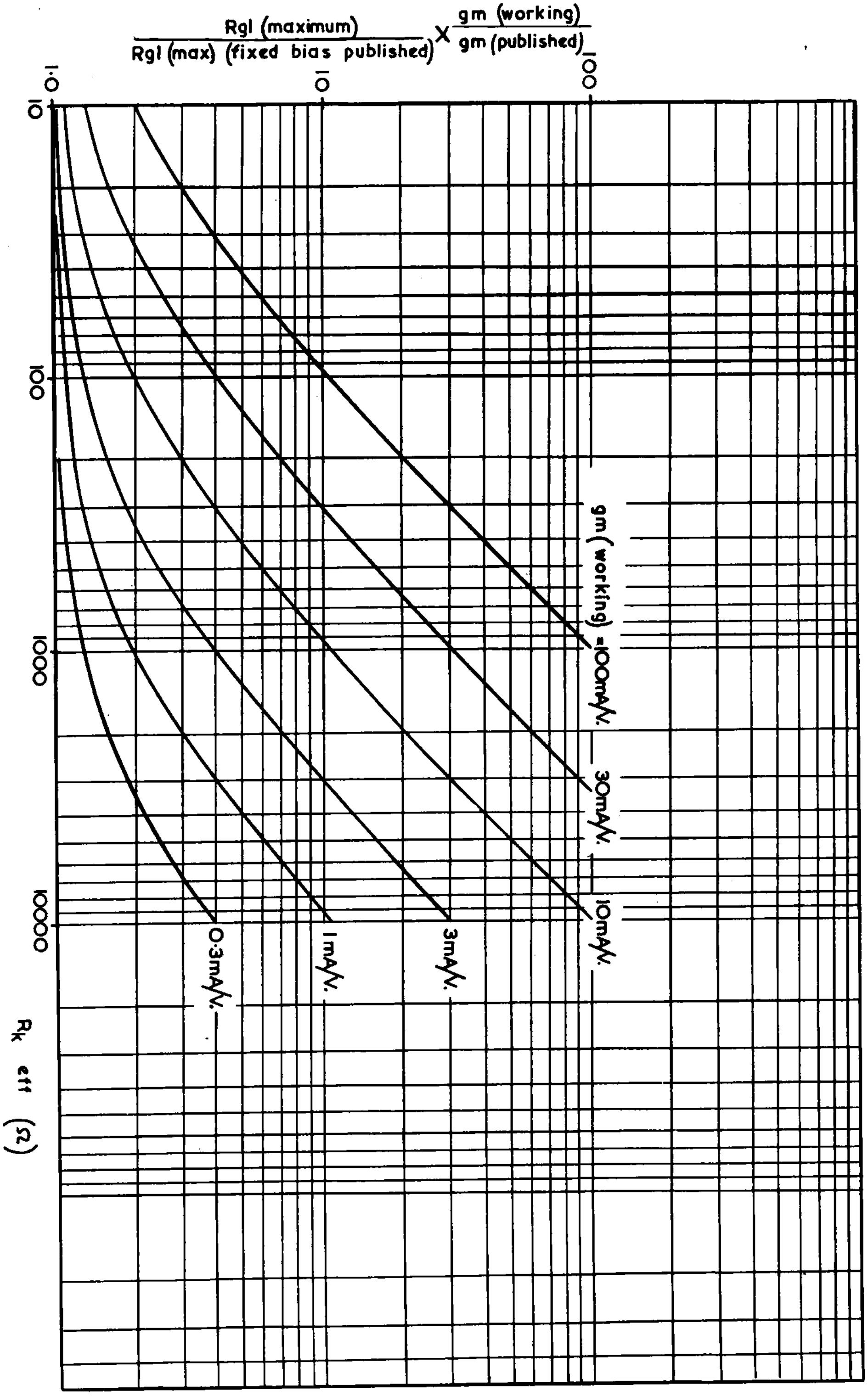
$$\frac{R_{g1} \text{ (maximum)}}{R_{g1} \text{(max) (Fixed bias published)}} \times \frac{g_m \text{ (working)}}{g_m \text{ (published)}} = 16$$

$$\text{Therefore } R_{g1} \text{ maximum} = 16 \times 0.25 \times 10^6 \times \frac{5.2}{3.5} = 6M.$$

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:-

$$\frac{R_{g1} \text{ (maximum)}}{R_{g1} \text{ (max) (fixed bias published)}} = \frac{g_m \text{ (published)}}{g_m \text{ (w: eff.)}}$$

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.


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)