ELECTRONIC VALVE SPECIFICATIONS

SPECIFICATION MOA/CV4506
ISSUE 2 DATED 24th AUGUST, 1960

AMENDMENT NO.1

Page 1 CAPACITANCES (pF)

Cag1 (Max.) Shielded

Amend "0.015" to "0.017"

November, 1960 D.L.R.D.(T)

N.46448/D

ELECTRONIC VALVE SPECIFICATIONS

SPECIFICATION MOA/CV4506

ISSUE 2 DATED 24TH AUGUST 1960

AMENDMENT NO.2

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'

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

7 Remove and destroy page 7

1962

489 D.L.R.D.(T)

VALVE ELECTRONIC

CV4506

MINISTRY OF AVIATION - D.L.R.D.(T)

Specification MOA/CV4506	SECURITY	
	Specification	Valve
Issue 2 dated 24th August, 1960	UNCLASSIFIED	UNCLASSIFIED
To be read in conjunction with K.1001, B.S.448 and B.S.1409		

→ Indicates a change

TYPE OF VALVE - Reliable Sub-Miniature Variable - μ H.F. Pentode with Flying Leads

CATHODE - Indirectly - heated

ENVELOPE - Glass

PROTOTYPE - CV475, VX7507

MARKING

See K.1001/4

BASE

See B.S.448/B8D/F/1.1

RATINGS (Note A)

(All Limiting values are absolute)

			Note
Heater Voltage	(V)	6.3	
Heater Current	(mA)	175	
Max. Heater - Cathode Voltage, Cathode +ve	(V)	100	
Cathode -ve	(V)	100	B
Max. Anode Voltage (Ia = 0)	(V)	350	
Max. Screen Voltage (Ig2 = 0)	(V)	350	
Max. Negative Grid Voltage	(V)	100	
Max. Operating Anode Voltage (pa.max.)	(V)	190	
Max. Operating Screen Voltage (pg2.max.)	(V)	190	
Max. Anode Dissipation	(W)	1.1	
Max. Screen Dissipation	(W)	0.55	
Max. Positive Grid Current	(μA)	0	
Max. Cathode Current	(mA)	14.5	
Max. Grid Circuit Resistance (Fixed Bias)	(M)	0.25	F
(Auto Bias)	(M)	0.5	F
Max. Vibration (100 Hours duration Max.)	(g)	5	C
(10 Minutes duration Max.)	(g)	20	D
Max. Shock (short duration)	(g)	500	
Max. Bulb Temperature	(°C)	165	
Min. Operating Pressure	(mm.Hg.)	55	
Max. Ambient Storage Temperature Range	(°C)	-60/+85	

Typical Operating Conditions

Measured at Va = Vg2 = 100V; Vg1 = -1.1 V

Anode Current	(mA)	7.2
Screen Current	(mA)	2.0
Mutal Conductance	(mA/V)	4.5
Inner μ		34

CAPACITANCES (pF)

Cin (Nom.) Shielded	4.3
Cout (Nom.) Shielded	3.4
Cag1 (Max.) Shielded	0.015

CONNECTIONS

Lead	Electrode	
1	Grid	g1
2	Cath.Supp.Sh.	k+g3+s
3	Heater	h
4	Cath.Supp.Sh.	k+g3+s
5	Anode	a
6	Heater	h
7	Screen	g2
8	Cath.Supp.Sh.	k+g3+s

DIMENSIONS

See B.S.448/B8D/F/2.1
Size Ref.No.2

Dimensions (mm)	Min.	Max.
A Seated Height	29.0	32.0
B Overall Length	-	38.1
C Diameter	9.3	10.16
D Lead length (Note E)	38.1	-

MOUNTING POSITION

Any

TYPE APPROVAL

See K1001/15
Minimum quantity for submission 225
See Note G

APPLICATIONS DATA

Issue 1 - See section following page 7.

NOTES

See next page.

NOTES

A. Caution to Electronic Equipment Design Engineers: Special attention should be given to the temperature of valves to be operated in Guided Weapons and Aircraft. Reliability will be seriously impaired if the maximum bulb temperature is exceeded. The life expectancy may be reduced if conditions other than those specified for life test are imposed on the valve and will be reduced appreciably if absolute maximum ratings are exceeded. Both reliability and performance will be jeopardized if heater voltage ratings are exceeded; life and reliability performance are directly related to the degree that regulation of the heater voltage is maintained at its centre-rated value. Under no circumstances should the heater voltage supply be allowed to deviate more than ± 5% from the rated value.

B. For greater reliability, the potential between heater and cathode, when cathode is negative with respect to heater, should not be allowed to exceed 10 volts.

C. The maximum peak acceleration under continuous random vibration conditions specified assumes that the vibration frequency components are varying continuously over the band 10 to 1,000 cycles/sec in a random manner.

D. The maximum peak acceleration under short term random vibration conditions specified assumes that the vibration frequency components are varying continuously over the band 10 to 1,000 cycles/sec. in a random manner.

E. Direct soldered connections to the leads must be at least 5 mm. from the seal and any bending of the leads must be at least 1.5 mm. from the seal.

F. For greater reliability during use, the grid circuit resistance should be kept to a minimum.

G. When submitting for Type Approval the samples must be drawn from a lot which has met the requirements of the specification. The manufacturer shall provide the lot results, together with detailed measurements on the samples as required by the Type Approval Authority.

TESTS

CV4506

TO BE PERFORMED IN ADDITION TO THOSE APPLICABLE IN K.1001

TESTS IN ANY ONE GROUP SHALL BE PERFORMED IN THE SPECIFIED ORDER

TEST CONDITIONS - UNLESS OTHERWISE SPECIFIED

Vh(V)	Va(V)	Vg2(V)	Vg1(V)
6.3	100	100	-1.1

K1001	TEST	TEST CONDITIONS	AQL %	INSP. LEVEL	SYM-BOL	LIMITS MIN.	LAL	BOGEY	UAL	MAX.	AID	UNITS
AIX/2.1	GROUP A											
	Visual Inspection	Notes: 1, 2 No voltages		100%								
5.14	Inoperatives			100%								
	Insulation	Va-all = -300V		100%	R	200	-	-	-	-	-	M
		Vg2-all = -300V		100%	R	200	-	-	-	-	-	M
		Vg1-all = -100V		100%	R	200	-	-	-	-	-	M
	Reverse Grid Current (1)	Rg1 = 500 k max. Vg1 = -2V		100%	Ig1	-	-	-	-	0.3	-	µA
	Vibration Noise (1)	Notes: 2, 3 Acceleration = 15g peak min. Frequency = 50 c/s Rk = 120 Ck = 1000 µF min. Rg1 = 0 Va(b) = 250V Vg2 = 100V (Note: 4) Ra = 22k		100%	V_{out}	-	-	-	-	120	-	mV r.m.s.
AIX/2.2		Note 5										
AIX/2.3												
	GROUP B											
5.3	Heater-Cathode Leakage Current	Vhk = ± 100V	0.4	II	Ihk	-	-	-	-	10	-	µA
				V2	Ihk	-	-	-	2	-	-	µA
	Anode Current		0.4	II	Ia	4.0	-	7.2	-	10.4		mA
				V2	Ia	-	6.05	-	8.35		2.6	mA
	Screen Current		0.4	II	Ig2	0.25	-	2.0	-	3.75	-	mA
				V2	Ig2		1.39	-	2.61	-	1.4	mA
	Mutual Conductance (1)		0.4	II	gm	2.75	-	4.5	-	6.25	-	mA/V
				V2	gm	-	3.88	-	5.12	-	1.4	mA/V
	GROUP C											
	Heater Current		2.5	I	Ih	160	-	175	-	190	-	mA
	Mutual Conductance (2)	Vg1 = -14V	1.0	I	gm	10	-	-	-	75	-	µA/V
	Change of Mutual Conductance (1)	Vh = 5.7V Vg1 = 0 Rk = 120 Ck = 2000 µF Note 6	2.5	I	Δgm	-	-	-	-	15	-	%

K1001	TEST	TEST CONDITIONS	AQL %	INSP. LEVEL	SYMBOL	LIMITS MIN.	LAL.	BOGEY	UAL	MAX.	ALD	UNITS
	GROUP D											
	Reverse Grid Current (2)	Vh = 6.9V; Va = Vg2 = 190V Ia = 5.8mA; Vg1 or Rk adjust Rg1 = 500 k max. Note: 7	2.5	Code G	Ig1	-	-	-	-	1.0	-	µA
5.9	Capacitances	Measured on a 1 Mc/s bridge valve mounted in a fully screened socket. Shielded Note: 8	2.5	Code G	Cin	3.8	-	-	-	4.8	-	pF
					Cout	2.9	-	-	-	3.9	-	pF
					Cag1	-	-	-	-	0.017	-	pF
	GROUP E											
AIX/ 2.4.2.3	Lead Fragility	No voltages	1.0	Code I								
AIX/ 2.4.2.1	Glass Strain	No voltages Note: 9	2.5	Code G								
	Vibration Noise (2)	Notes: 3, 10		V3	V_{out}	-	-	-	30	-	-	mV r.m.s.
	Vibration Fatigue	Acceleration = 5g peak min. Time = 200 hours Note: 11		Code L								
	Vibration Noise (3)	Note : 12 Acceleration = 20g peak min. Rk = 120; Ck = 1000 µF min. Rg1 = 0; Ra = 22k; Va(b) = 250V Vg2 = 100V (Note: 4)										
		Frequency = (1) 60 - 120 c/s			V_{out}	-	-	-	500	-	-	mV (pk-pk)
		(2) 120 - 250 c/s			V_{out}	-	-	-	500	-	-	mV (pk-pk)
		(3) 250 - 500 c/s			V_{out}	-	-	-	500	-	-	mV (pk-pk)
		(4) 500 - 1000 c/s			V_{out}	-	-	-	500	-	-	mV (pk-pk)
		(5) 1000-2000 c/s			V_{out}	-	-	-	1000	-	-	mV (pk-pk)
	Post Vibration Noise (3) Test:	Combined AQL	2.5									
	Heater-Cathode Leakage Current	Vhk = ± 100V	1.0		Ihk	-	-	-	-	10	-	µA
	Reverse Grid Current (1)	Rg1 = 500k max Vg1 = -2V	0.25		Ig1	-	-	-	-	0.5	-	µA
	Mutual Conductance (1)		1.0		gm	2.55	-	-	-	6.25	-	mA/V
	Vibration Noise (1)	As in Group A. Note : 3	1.0		V_{out}	-	-	-	-	300	-	mV r.m.s.
	Catastrophics	Note : 13	0.25									
AIX/ 2.4.2.4.3.	Shock	Hammer Angle = 30° No Voltage (T/A only)										
	Post Shock Tests	As for Post Vibration Noise (3) Tests										

TESTS (Contd.)

CV4506

K1001	TEST	TEST CONDITIONS	AQL %	INSP. LEVEL	SYMBOL	LIMITS MIN.	LAL	BOGEY	UAL	MAX.	ALD	UNITS
	GROUP F											
AVI/5	Life	Vg1 = 0V Vhk = 135V heater positive Rg1 = 470k Rk = 120										
AVI/5.1	Stability Life											
	Change in Mutual Conductance (1)		1.0	I	Δgm	-	-	-	-	10	-	%
AVI/5.3	Intermittent Life											
	Test Point 200 hours	Combined AQL	4.0	Code I								
5.14	Inoperatives	Note: 14	0.25									
	Heater-Cathode Leakage Current	Vhk = ± 100V	1.5		Ihk	-	-	-	-	10	-	μA
	Reverse Grid Current (1)	Rg1 = 500k max. Vg1 = -2V	1.0		Ig1	-	-	-	-	0.3	-	μA
	Mutual Conductance (1)		1.0		gm	2.55	-	-	-	6.25	-	mA/V
	Average Change of Mutual Conductance(1)				$\overline{\Delta gm}$	-	-	-	-	10	-	%
	Insulation		2.5									
		Va-all = -300V			R	100	-	-	-	-	-	M
		Vg2-all = -300V			R	100	-	-	-	-	-	M
		Vg1-all = -100V			R	100	-	-	-	-	-	M
	Test Point 1000 hours	Combined AQL	6.5	Code H								
5.14	Inoperatives		1.5									
	Heater-Cathode Leakage Current	Vhk = ± 100V	4.0		Ihk	-	-	-	-	10	-	μA
	Reverse Grid Current (1)	Rg1 = 500k max. Vg1 = -2V	1.5		Ig1	-	-	-	-	1.0	-	μA
	Mutual Conductance (1)		1.5		gm	2.35	-	-	-	6.25	-	mA/V
	Insulation		4.0									
		Va - all = -300V			R	50	-	-	-	-	-	M
		Vg1 - all = -100V			R	50	-	-	-	-	-	M
	Group G											
AIX/2.5	Electrical Re-test after 28 days holding period			100%								
5.14	Inoperatives		0.5									
	Reverse Grid Current (1)	Rg1 = 500k max. Vg1 = -2V	0.5		Ig1	-	-	-	-	0.3	-	μA
	Mutual Conductance (1)				gm	2.75	-	-	-	6.25	-	mA/V

NOTES

1. The valve shall be visually inspected for good workmanship, using a visual aid having a X10 magnification. Particular attention shall be paid to the following:-

   Structure quality, quality of welds, quality of lead tinning, external dimensions and shape, and freedom from harmful loose particles.

2. This test may be done alternatively, in Group C, at the discretion of the manufacturer.

3. The valve shall be mounted so that the direction of vibration is parallel to the minor axis of the electrode structure. The test shall be of sufficient duration to obtain a steady reading of noise output.

4. Vg2 may be obtained from the 250 volt line via a resistor of 75k decoupled by a 2μF capacitor.

5. At this stage the lot shall be formed. It shall be an identifiable lot not exceeding 5,000 valves. Normal Sampling (Single) shall apply.

6. The change in mutual conductance is expressed: $\frac{(gm \text{ at } 6.3V) - (gm \text{ at } 5.7V)}{(gm \text{ at } 6.3V)} \times 100\%$

7. For this test, the valve shall be pre-heated for 5 minutes under the test conditions. Ig1 shall not be rising or out of limit after a total of 5 minutes.

8. The capacitance Test Jig connections shall be as follows:-

Test	Links to H.P.	Links to L.P.	Links to E
Cin	1	2,3,4,6, 7,8, Sh.	5
Cout	5	2,3,4,6, 7,8, Sh.	1
Cag1	1	5	2,3,4,6, 7,8 Sh.

9. This is a destructive test and valves used for this test will not be accepted for delivery.

10. Test conditions as for Vibration Noise (1) in Group A.

11. The valves shall be randomly mounted on a vibrator mount in such a manner that each valve experiences an acceleration of at least 5g peak. The frequency of vibration shall be swept continuously over the range 60-1000 c/s at a rate of change of frequency not greater than 1 octave per minute. The heater supply shall be 6.6 V and switched approximately 8 minutes on 16 minutes off throughout the duration of the test. No other voltages are to be applied.

12. This test to be applied to the total sample previously subjected to the Vibration Fatigue Test. Each valve shall be mounted so that the direction of vibration is parallel to the minor axis of the electrode structure and shall be vibrated over the frequency range 60 - 2,000 c/s. swept once only at a rate of change of frequency not greater than 1 octave per 30 secs. The voltages to be recorded shall be the values of noise output at the maximum resonance in each of the specified frequency bands, as measured in terms of peak to peak voltage using an approved equipment. See page 7.

13. A valve shall be deemed to be catastrophic if it is either an inoperative as defined in K1001 Section 5.14, or has either or both the following defects:

   (i) Anode current outside the range ± 7½% of the bogey in Group B.

   (ii) Vibration noise output, as measured in Group A, greater than 1000 mV r.m.s.

14. Accept lot if 0 inoperatives in sample, reject lot if 2 or more inoperative. If 1 inoperative, take further sample of 50 and accept if no further inoperatives.

APPLICATIONS DATA

FOR

VALVE TYPE

CV4506

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

ISSUE 1 NOVEMBER 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

CV4506

CONTENTS.

		Page
Statistical Sampling.		
Statistical Aspects of CV4500 Specifications		4
Typical Operating Characteristic		5
Limiting Distributions of Major Characteristics		6
Maximum Range Distributions centred on Bogey		7
Grid Characteristics.		
Ia & Ig2	: Vg1 Va=Vg2=50V, 100V, 150V,	8
gm	: Vg1 Va=Vg2=50V, 100V, 150V	9
ra	: Vg1 Va=Vg2=50V, 100V, 150V	10
Anode & Screen Characteristics.		
Ia & Ig2	: Vg2=50V For nominal valve	11
Ia & Ig2	: Vg2=50V For bottom lmt. valve	12
Ia & Ig2	: Vg2=50V For top lmt. valve	13
Ia & Ig2	: Vg2=100V For nominal valve	14
Ia & Ig2	: Vg2=100V For bottom lmt. valve	15
Ia & Ig2	: Vg2=100V For top lmt. valve	16
Ia & Ig2	: Vg2=150V For nominal valve	17
Ia & Ig2	: Vg2=150V For bottom lmt. valve	18
Ia & Ig2	: Vg2=150V For top lmt. valve	19
Triode-connected Characteristics.		
Ia	: Vg1 Va=50V, 100V, 150V	20
Ia	: Va Vg1= -6V to +2V	21
u, gm, ra, Vg1	: Ia Va=50V	22
u, gm, ra, Vg1	: Ia Va=100V	23
u, gm, ra, Vg1	: Ia Va=150V	24
Dynamic Characteristics.		
Ia & Ig2	: Vg1 Va(b)=250V, Vg2=10-45V, Ra=100K	25
Ia & Ig2	: Vg1 Va(b)=250V, Vg2=10-45V, Ra=220K	26
Ia & Ig2	: Vg1 Va(b)=250V, Vg2=10-45V, Ra=470K	27
Ia & Ig2	: Vg1 Va=100V Vg2(b)=100V, Rg2=22K, 33K, 47K	28
Miscellaneous.		
Pa & Pg2	: Ambient Temperature	29
Bulb Hot Spot Temp.	: Ambient Temperature	30
Maximum permissible value of Grid to Cathode Resistor		31
" " " " " "		32

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

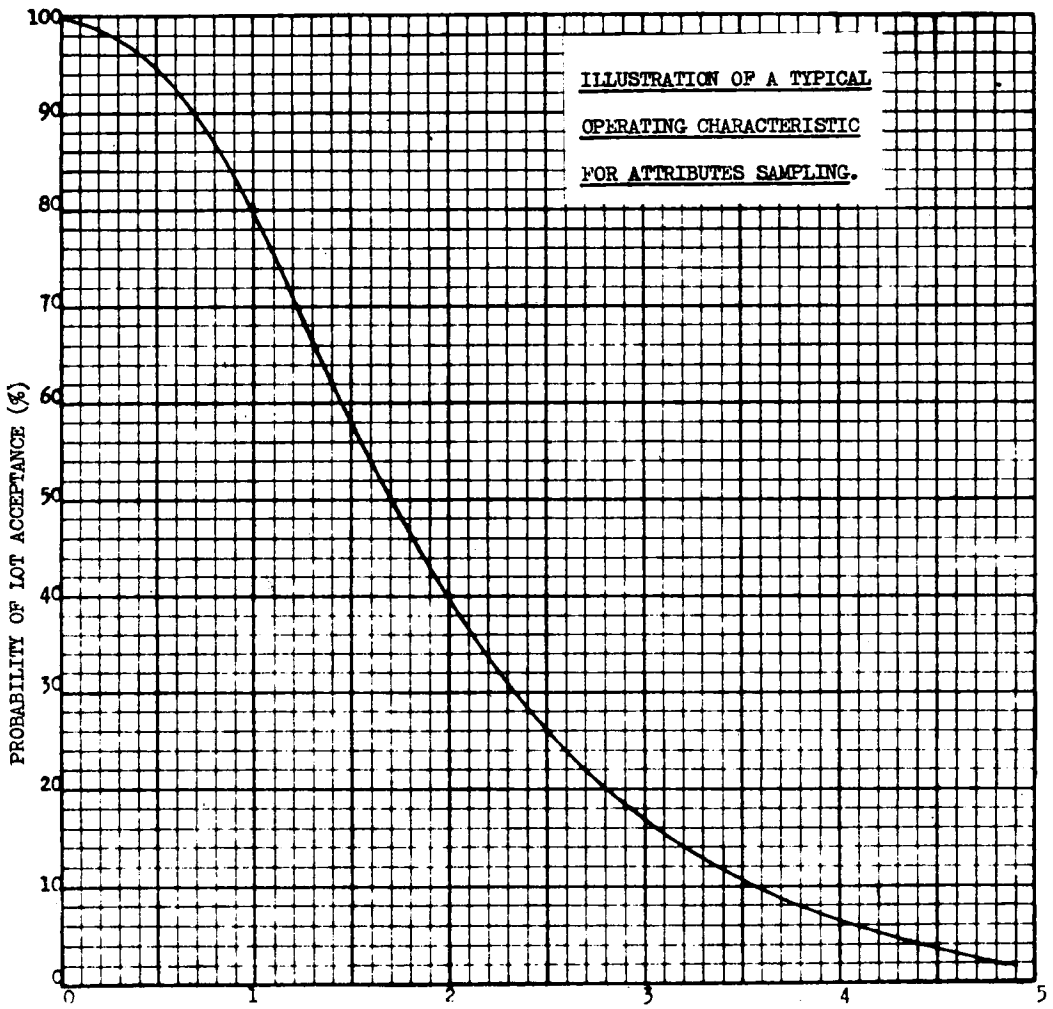
Illustrations of the limiting distributions for this valve, which would be just accepted by the above controls, are given on Pages 6 and 7. These show normal curves with the maximum permissible spread allowed by the ALD, centered on the LAL and UAL, respectively, and the maximum spread distributions,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

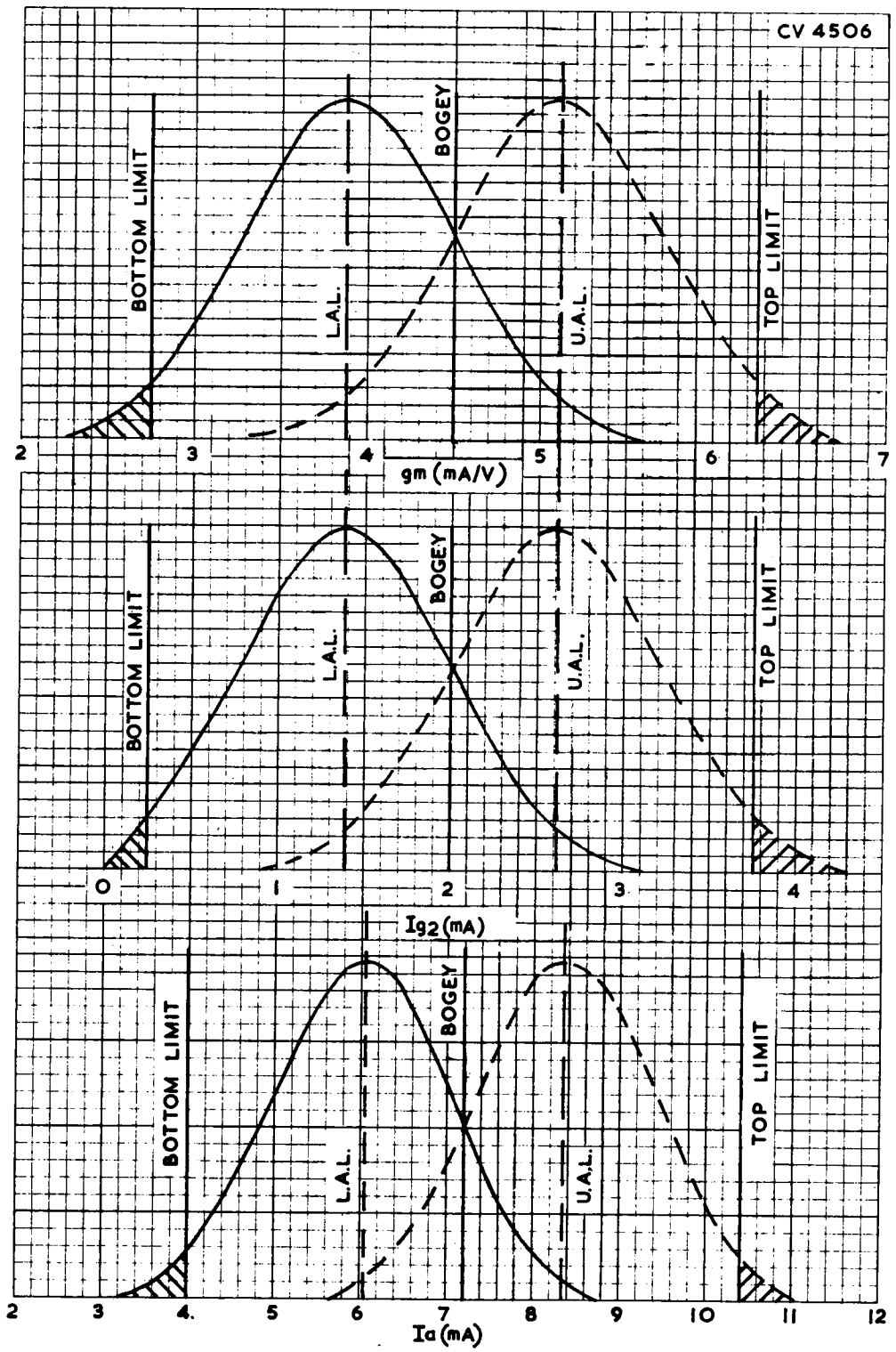
Typical Operating Characteristic

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).

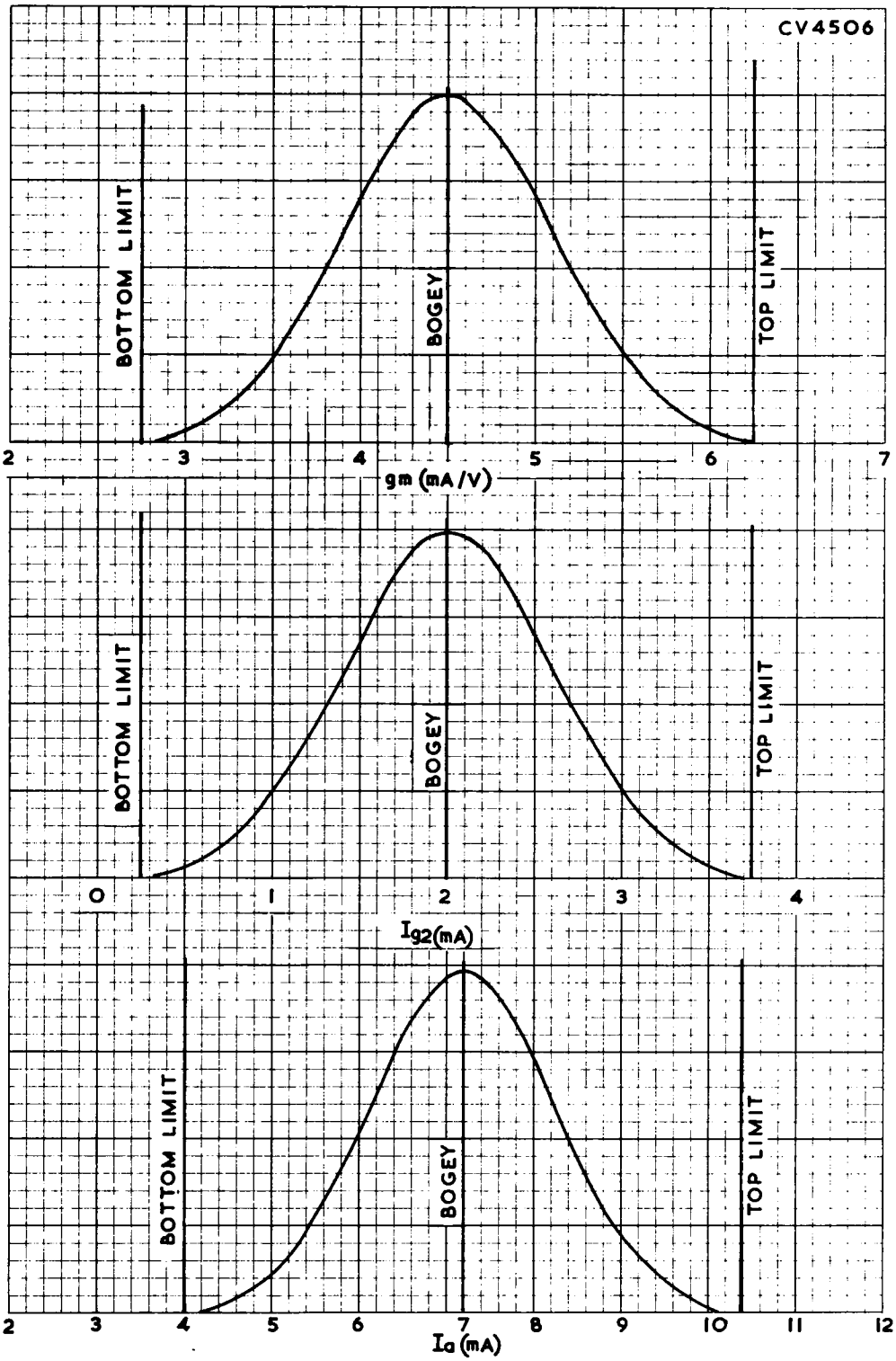


CV4506



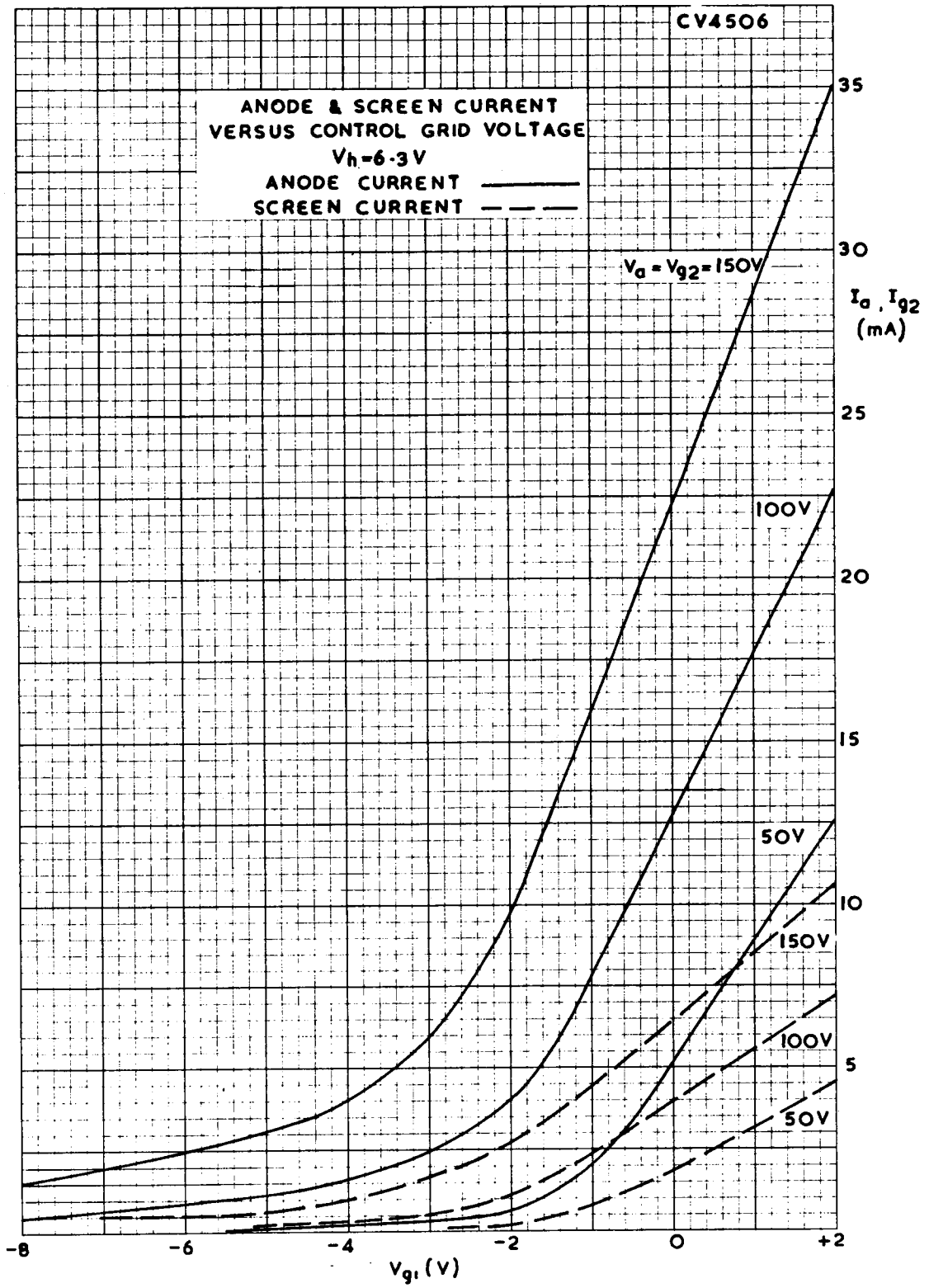
LIMITING DISTRIBUTIONS OF MAJOR CHARACTERISTICS

CV4506

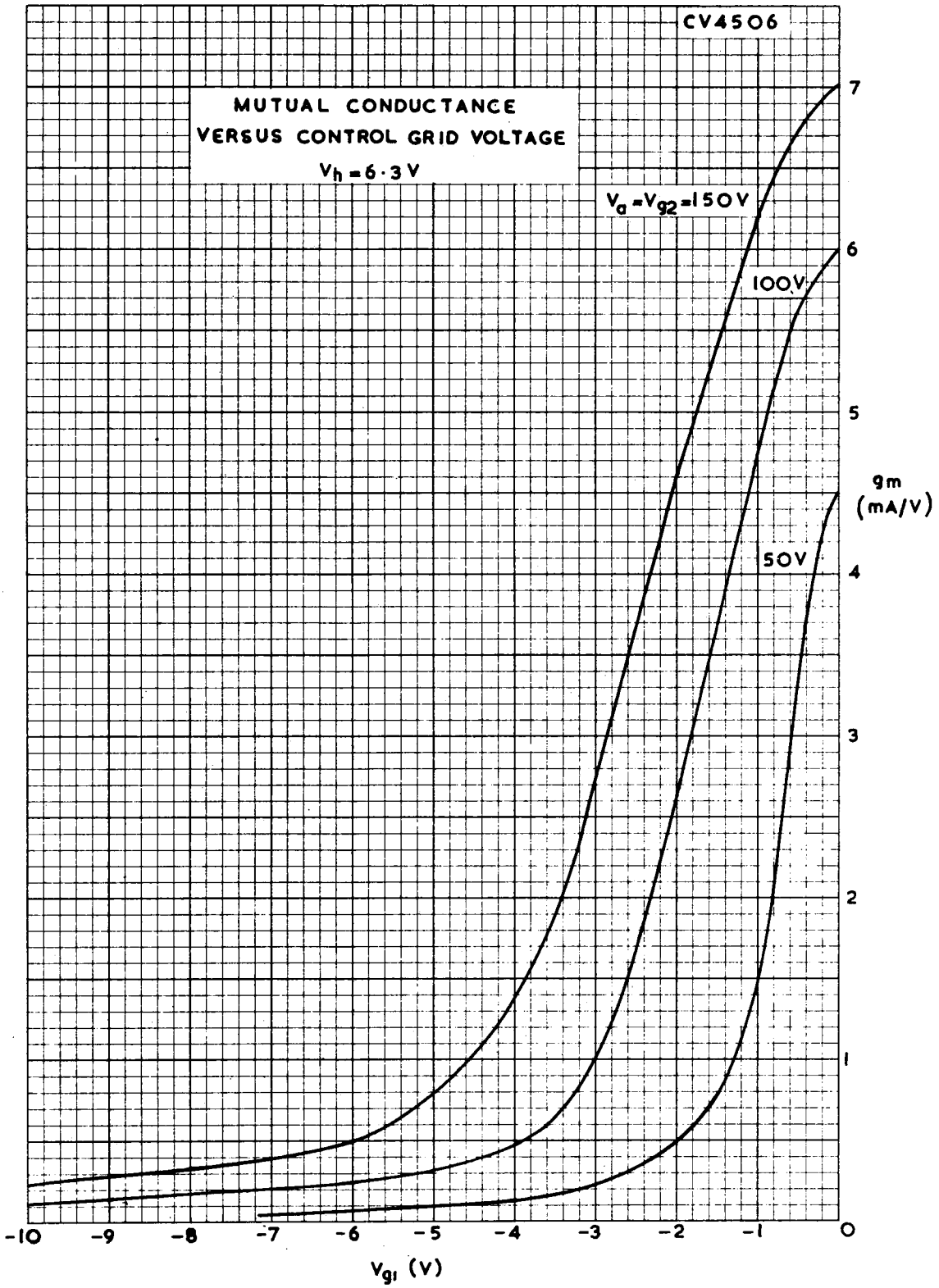


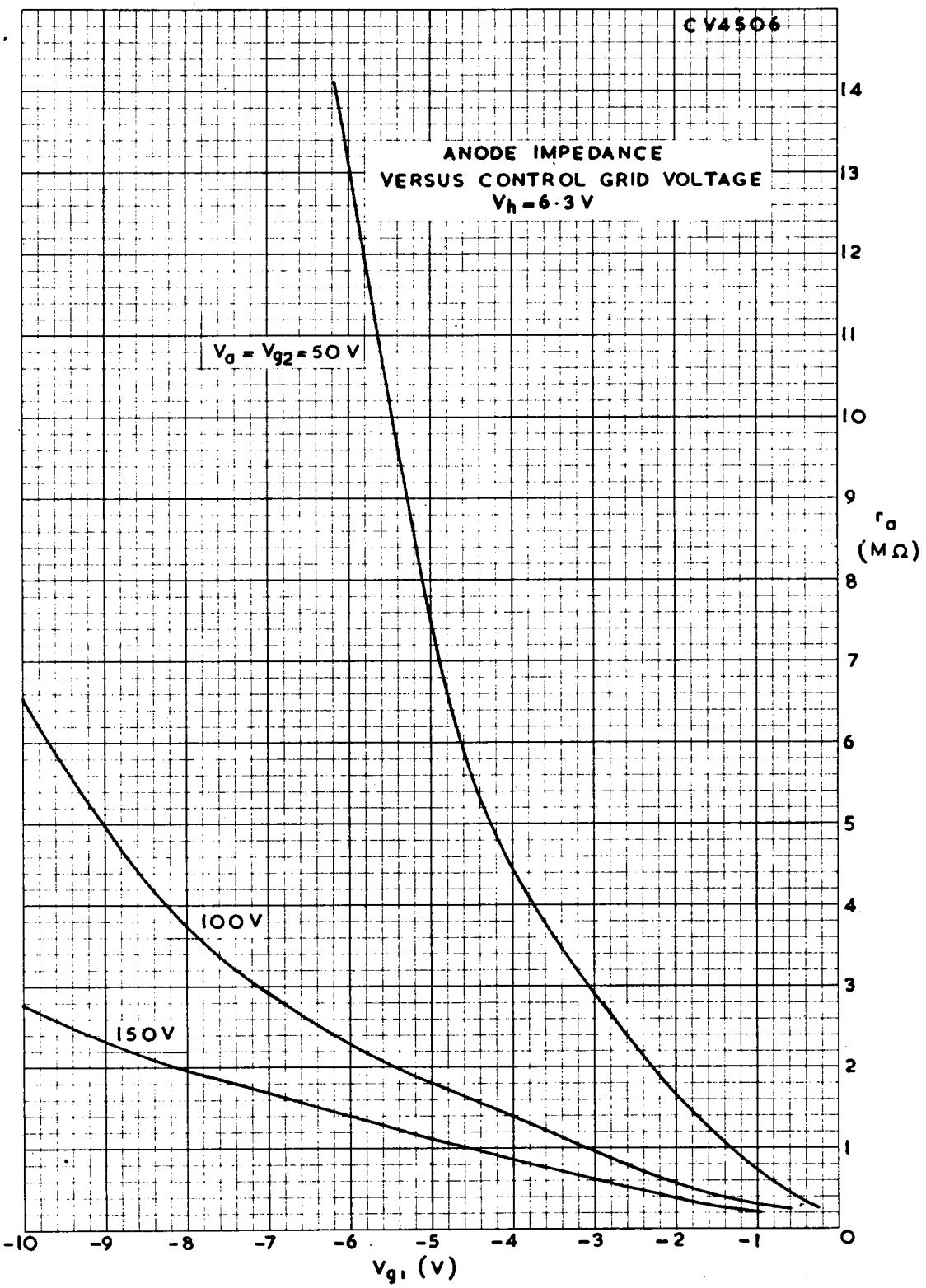
MAXIMUM ALLOWABLE SPREAD DISTRIBUTIONS CENTRED ON BOGEY

CV4506

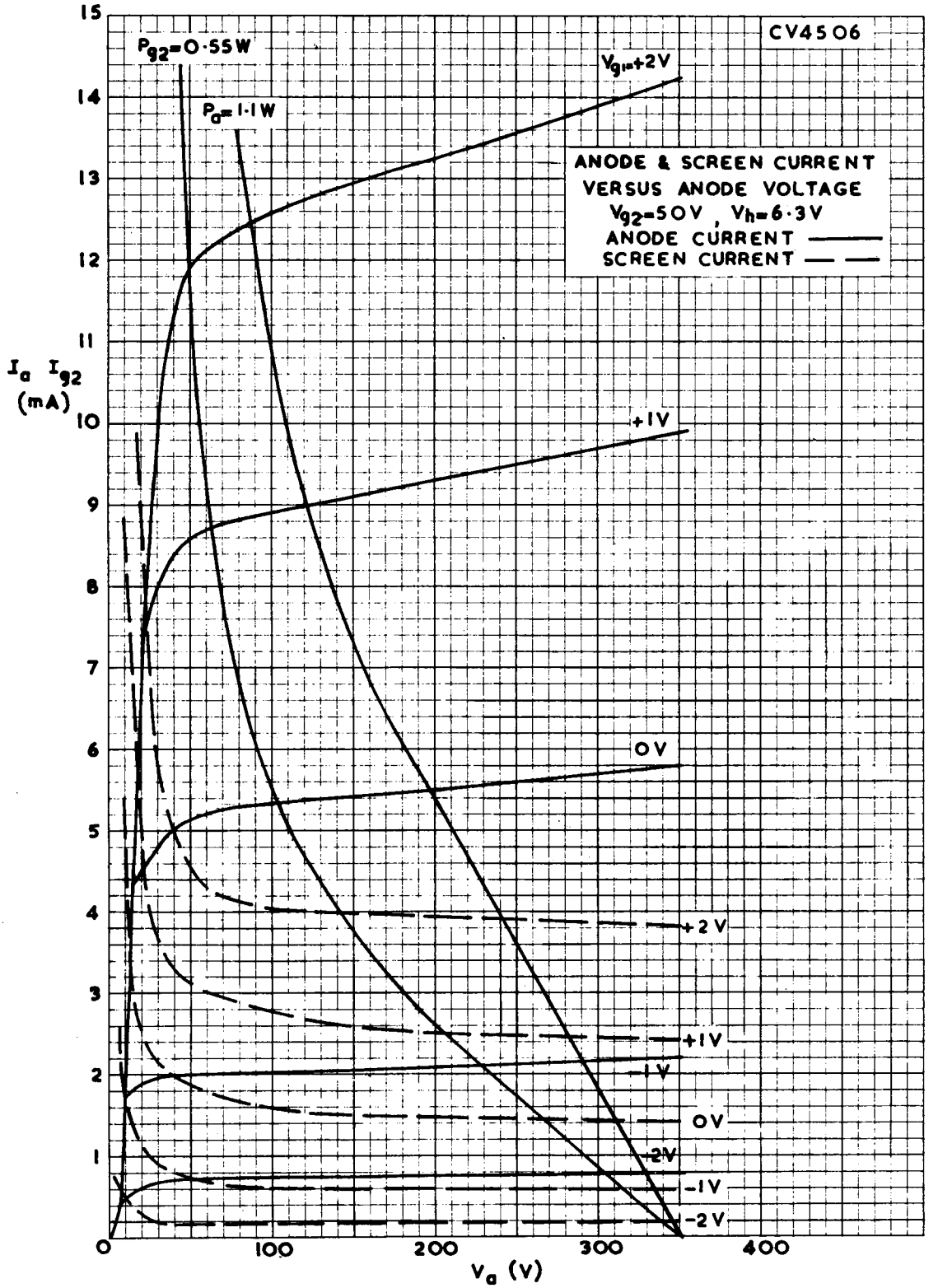

CV4506
ANODE & SCREEN CURRENT
VERSUS CONTROL GRID VOLTAGE
V_h=6·3 V
ANODE CURRENT
SCREEN CURRENT
$V_a = V_{g2}$=150V
100V
50V
150V
100V
50V
35
30
25
20
15
10
5
I_a, I_{g2} (mA)
-8
-6
-4
-2
0
+2
V_{g1} (V)

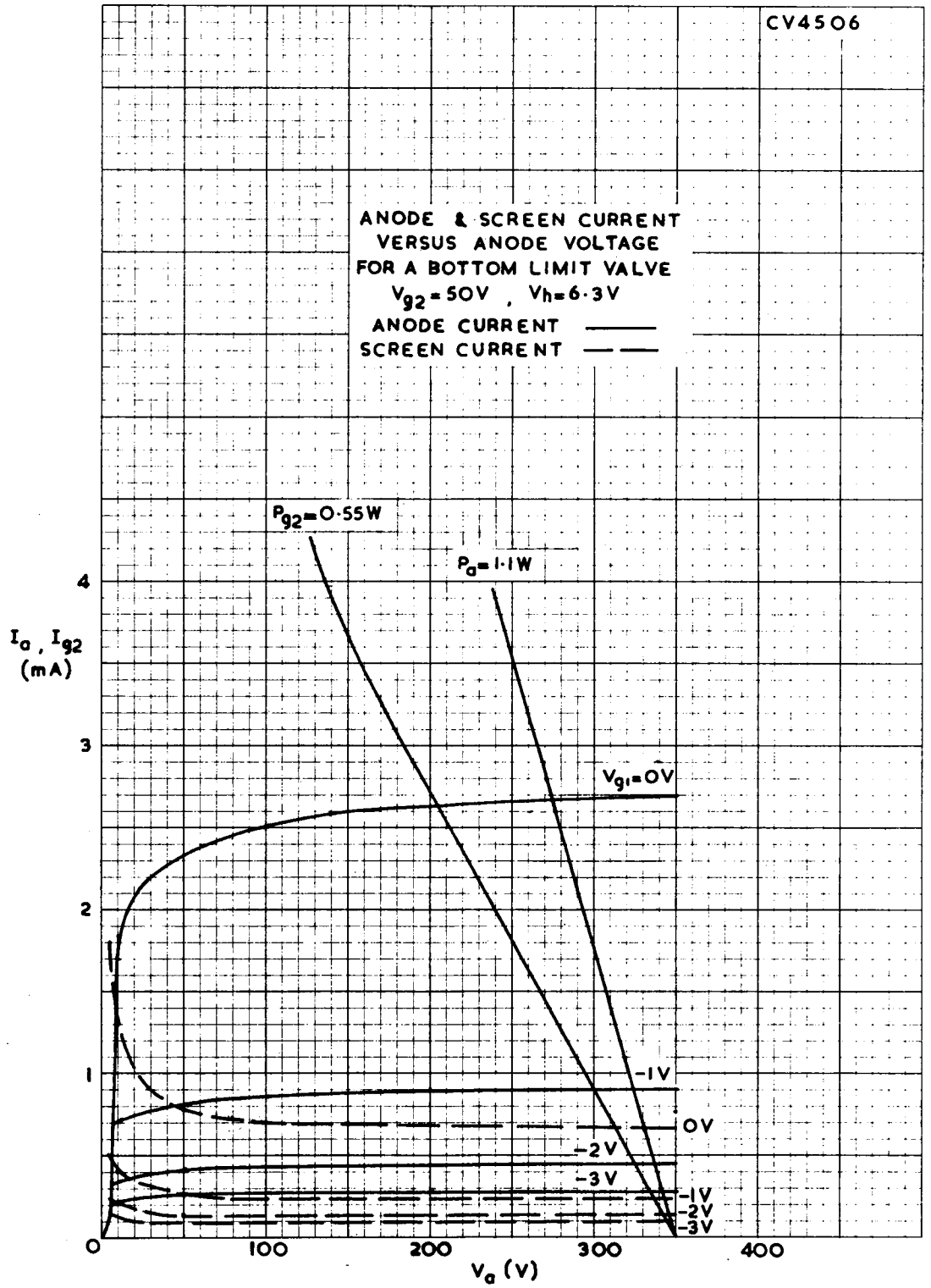
CV4506


CV4506
MUTUAL CONDUCTANCE
VERSUS CONTROL GRID VOLTAGE
$V_h = 6.3\,V$
$V_a = V_{g2} = 150\,V$
100V
50V
gm
(mA/V)
7
6
5
4
3
2
1
0
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
V_{g1} (V)

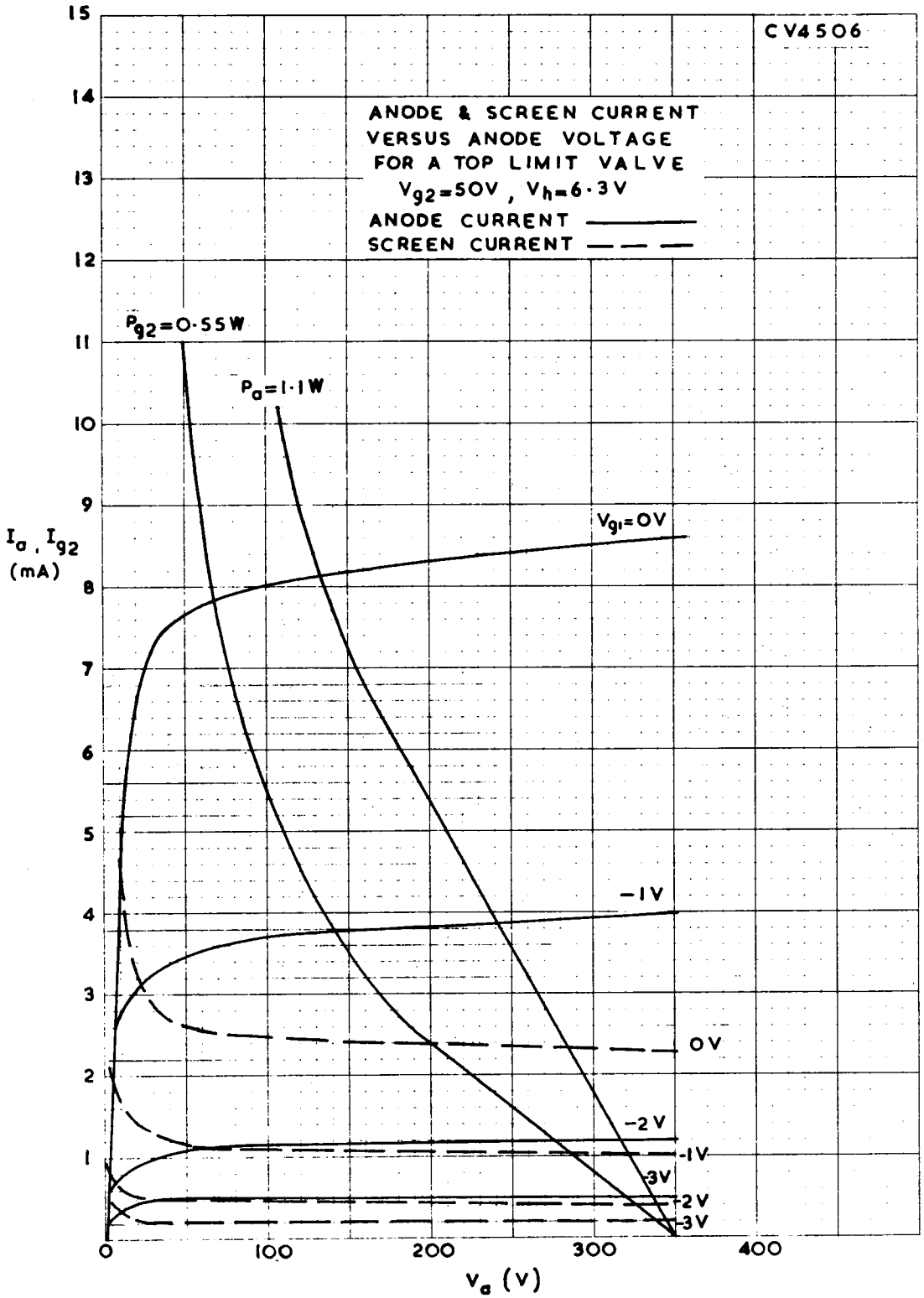

CV4506
ANODE IMPEDANCE
VERSUS CONTROL GRID VOLTAGE
$V_h = 6{\cdot}3\ V$
$V_a = V_{g2} = 50\ V$
100V
150V
r_a (MΩ)
V_{g1} (V)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1

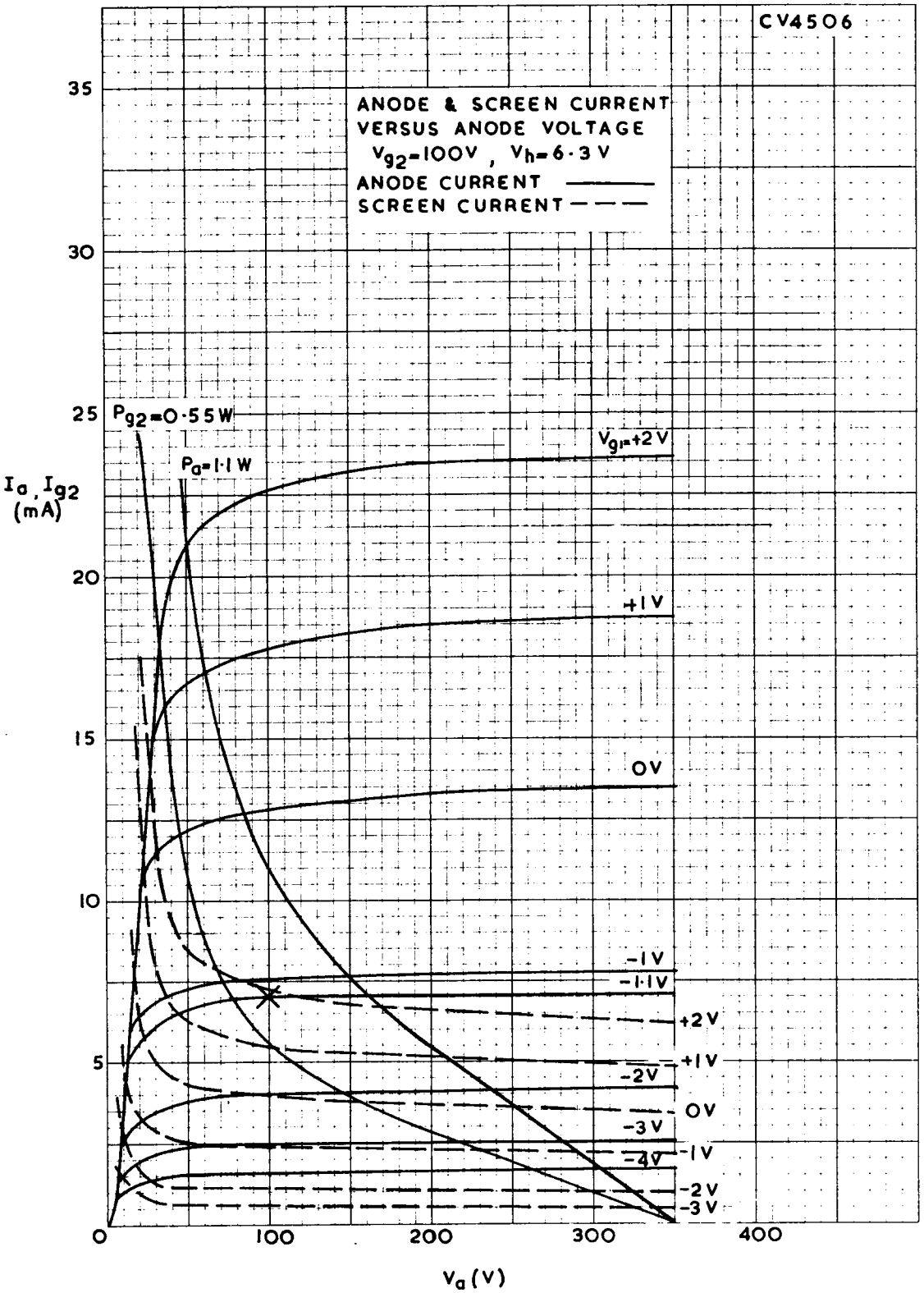
CV4506


CV4506
P_{g2}=0·55W
P_a=1·1W
V_{g1}=+2V
ANODE & SCREEN CURRENT
VERSUS ANODE VOLTAGE
V_{g2}=50V , V_h=6·3V
ANODE CURRENT
SCREEN CURRENT
+1V
0V
+2V
+1V
-1V
0V
-2V
-1V
-2V
I_a I_{g2} (mA)
V_a (V)
0
100
200
300
400
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

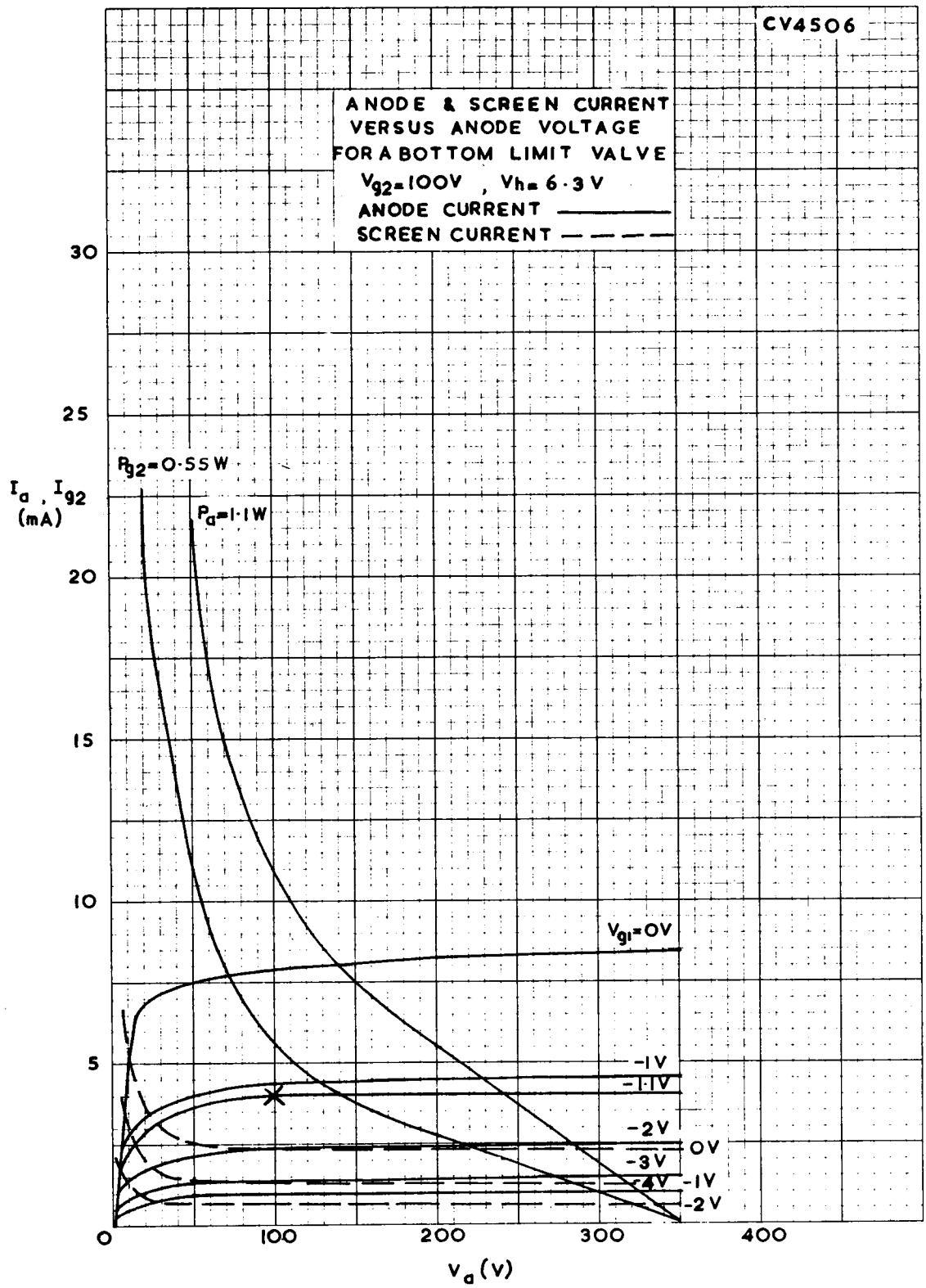

CV4506
ANODE & SCREEN CURRENT
VERSUS ANODE VOLTAGE
FOR A BOTTOM LIMIT VALVE
V_{g2} = 50V , V_h = 6·3V
ANODE CURRENT
SCREEN CURRENT
P_{g2} = 0·55W
P_a = 1·1W
V_{g1} = 0V
-1V
0V
-2V
-3V
-1V
-2V
-3V
I_a , I_{g2} (mA)
0
1
2
3
4
100
200
300
400
V_a (V)

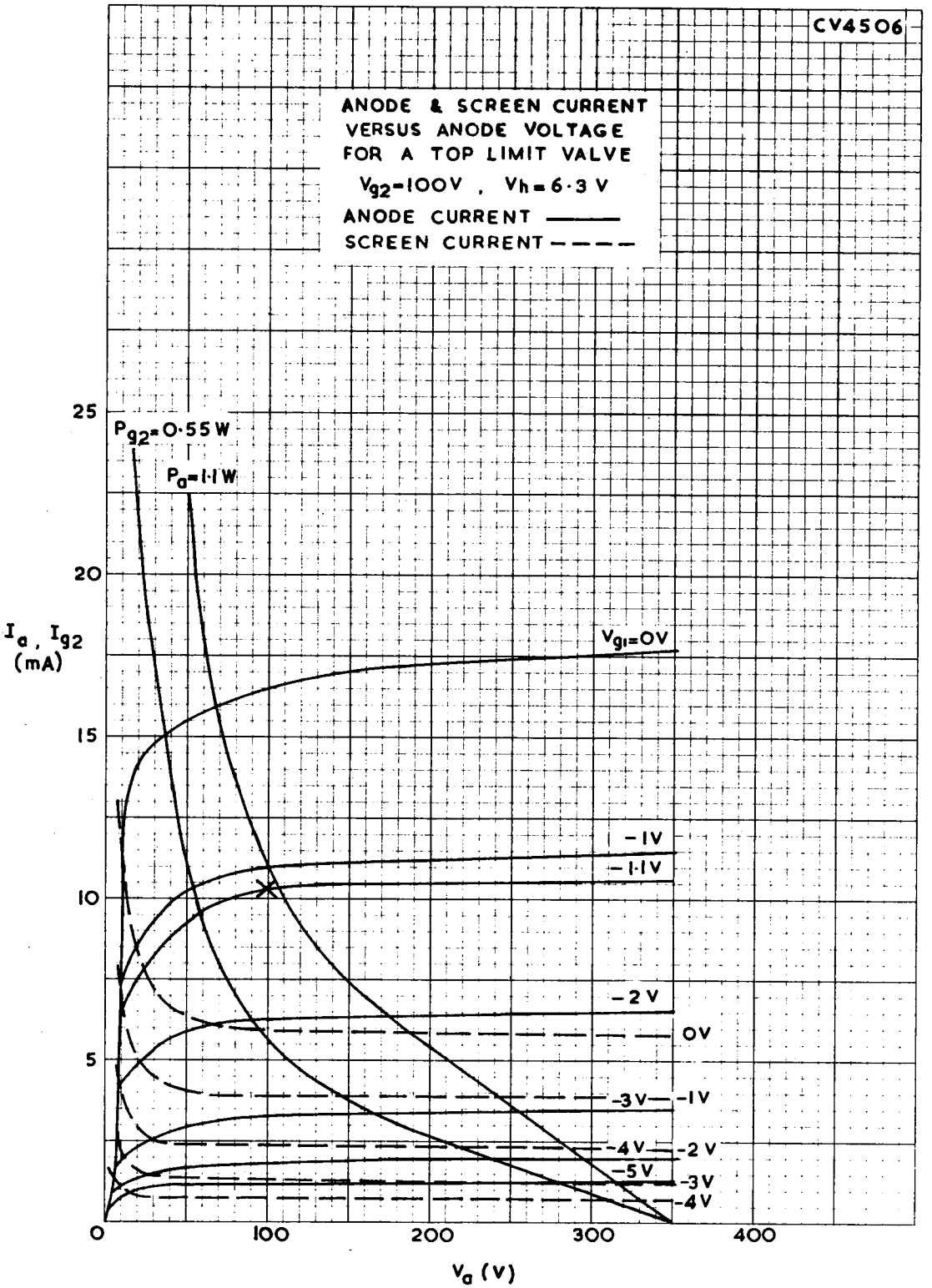
CV4506


CV4506
ANODE & SCREEN CURRENT
VERSUS ANODE VOLTAGE
FOR A TOP LIMIT VALVE
V_{g2}=50V , V_h=6·3V
ANODE CURRENT
SCREEN CURRENT
P_{g2}=0·55W
P_a=1·1W
V_{g1}=0V
-1V
0V
-2V
-1V
-3V
-2V
-3V
I_a , I_{g2} (mA)
V_a (V)
0
100
200
300
400
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

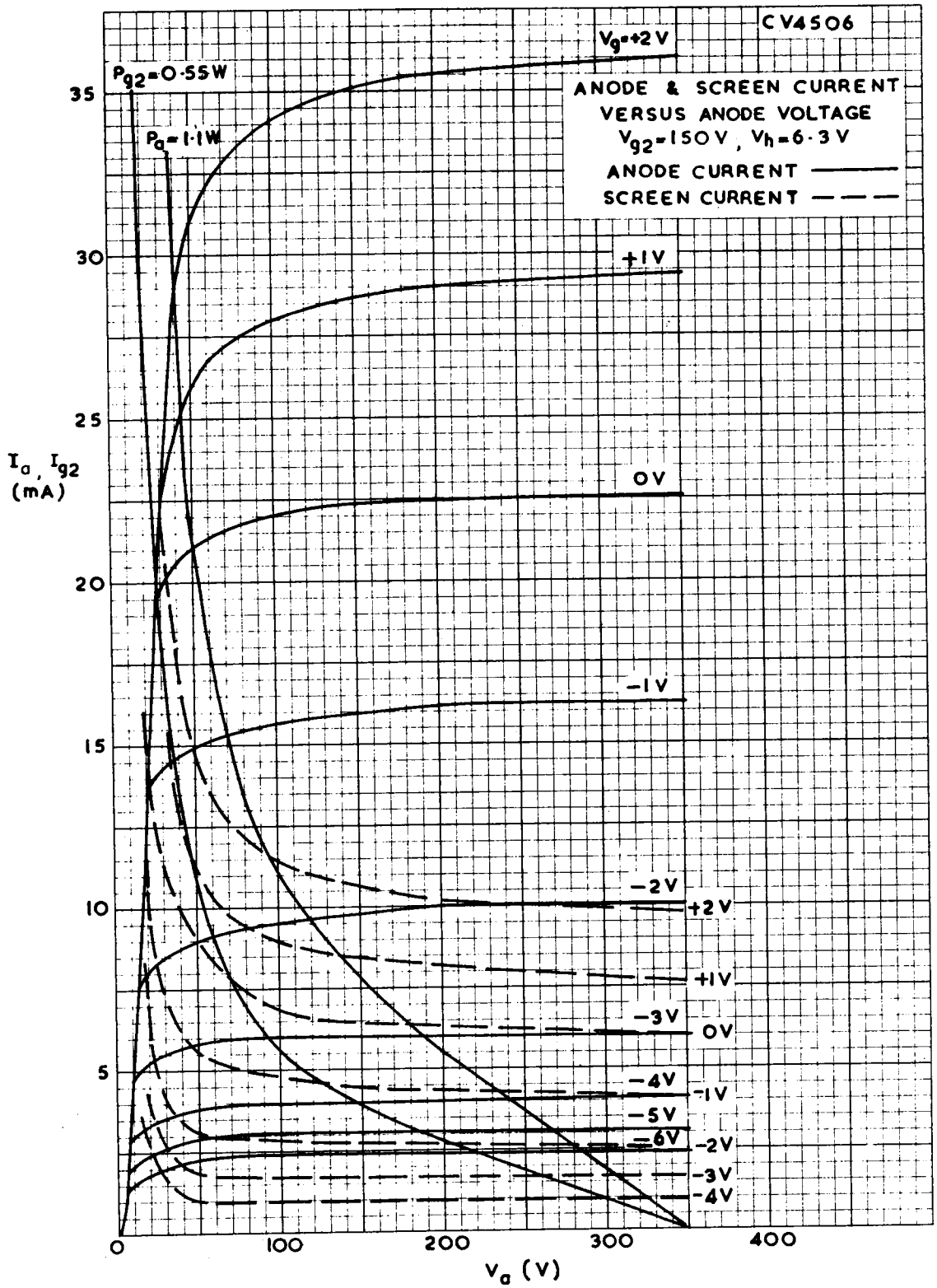

CV4506
ANODE & SCREEN CURRENT
VERSUS ANODE VOLTAGE
V_{g2}=100V , V_h=6·3 V
ANODE CURRENT
SCREEN CURRENT
P_{g2}=0·55W
P_a=1·1W
V_{g1}=+2V
+1V
0V
-1V
-1·1V
+2V
+1V
-2V
0V
-3V
-1V
-4V
-2V
-3V
I_a, I_{g2} (mA)
V_a (V)
0
5
10
15
20
25
30
35
100
200
300
400

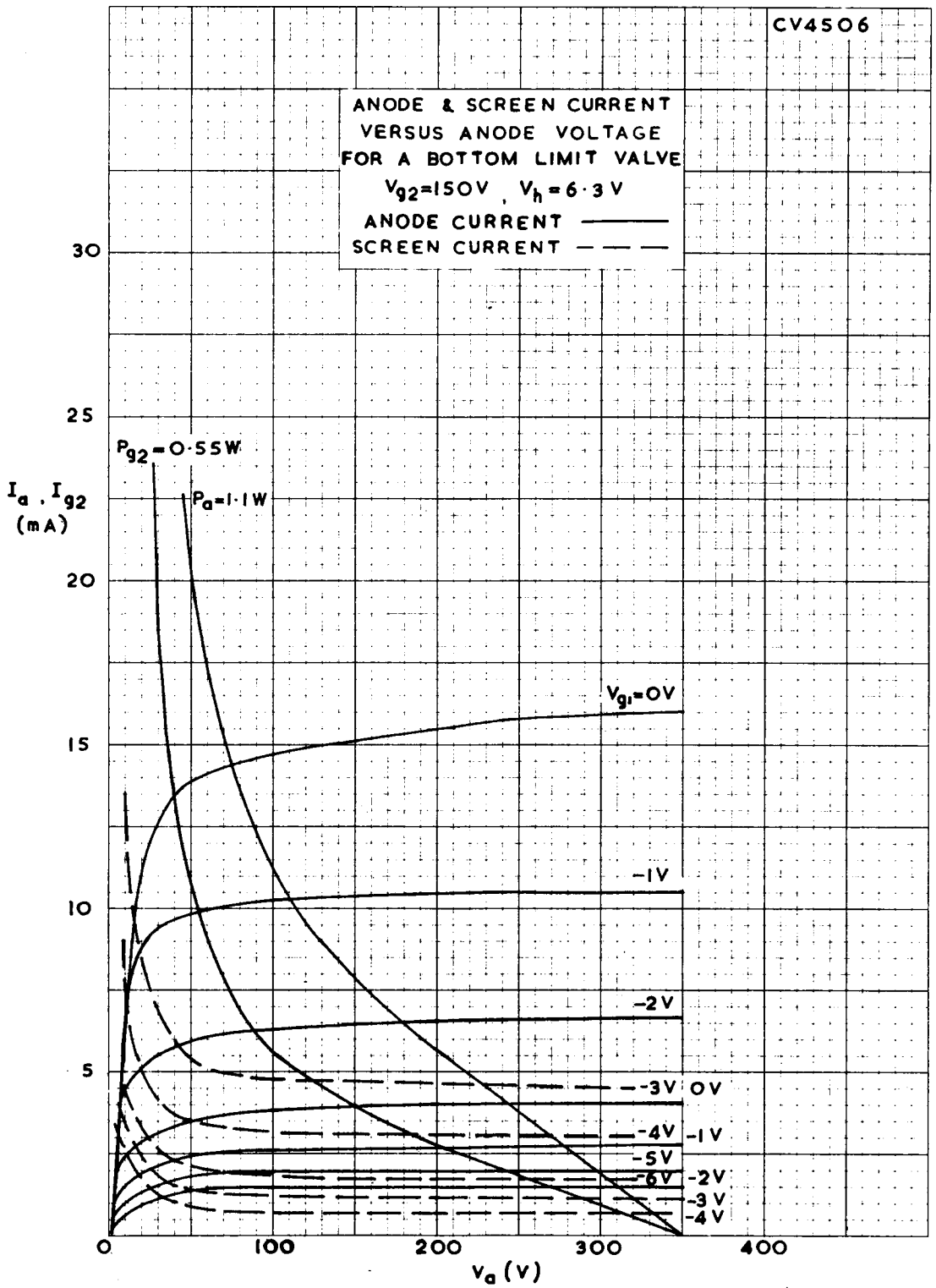
CV4506


CV4506
ANODE & SCREEN CURRENT
VERSUS ANODE VOLTAGE
FOR A BOTTOM LIMIT VALVE
V_{g2}=100V , Vh= 6·3 V
ANODE CURRENT
SCREEN CURRENT
P_{g2}=0·55W
P_a=1·1W
I_a , I_{g2} (mA)
V_{g1}=0V
-1V
-1·1V
-2V
0V
-3V
-4V
-1V
-2V
30
25
20
15
10
5
0
100
200
300
400
V_a (V)

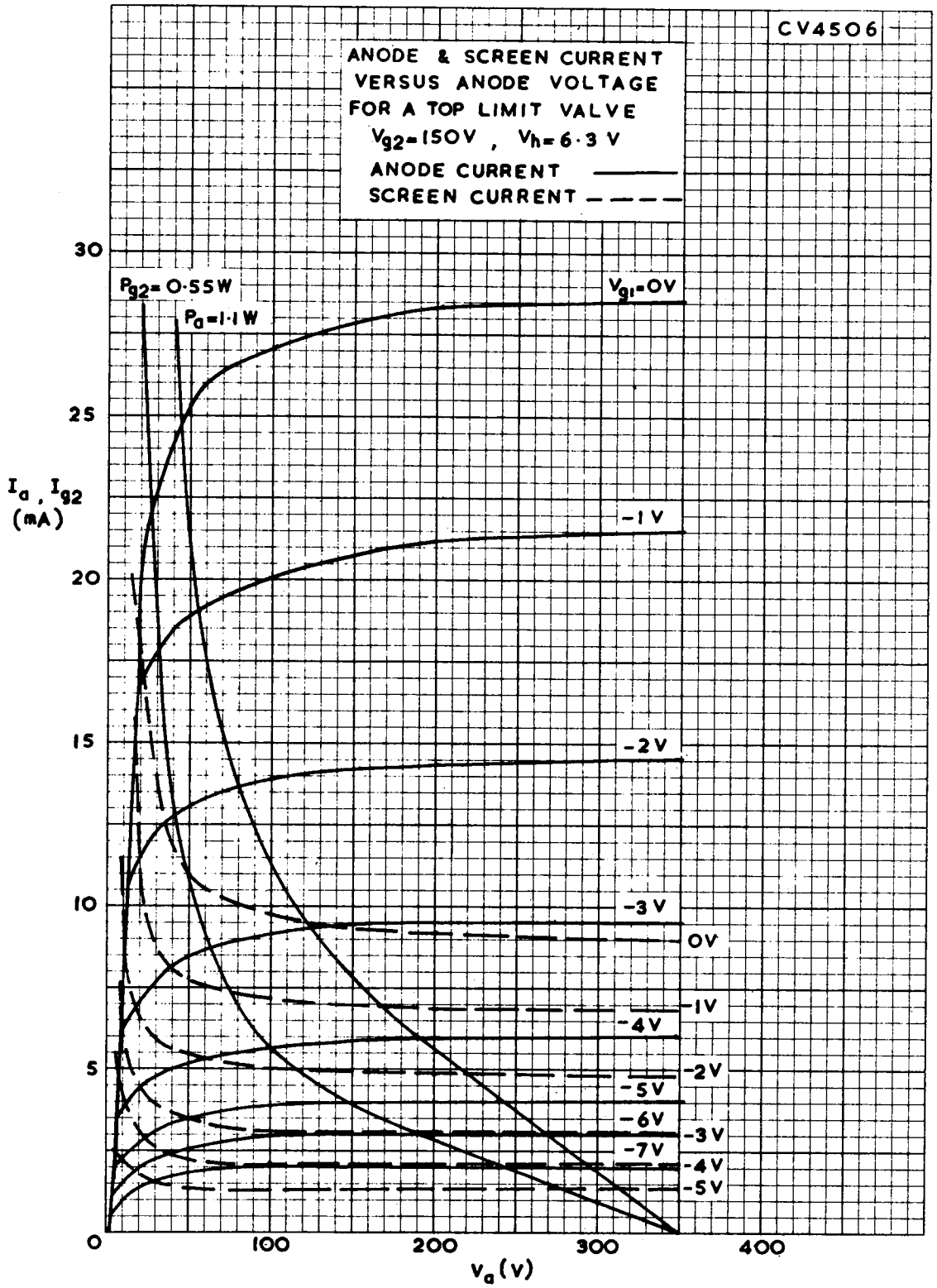

CV4506
ANODE & SCREEN CURRENT
VERSUS ANODE VOLTAGE
FOR A TOP LIMIT VALVE
V_{g2}=100V , V_h=6·3 V
ANODE CURRENT
SCREEN CURRENT
P_{g2}=0·55 W
P_a=1·1 W
V_{g1}=0V
-1V
-1·1V
-2 V
0V
-3V
-1V
-4V
-2 V
-5V
-3V
-4V
I_a , I_{g2} (mA)
V_a (V)
0
5
10
15
20
25
100
200
300
400

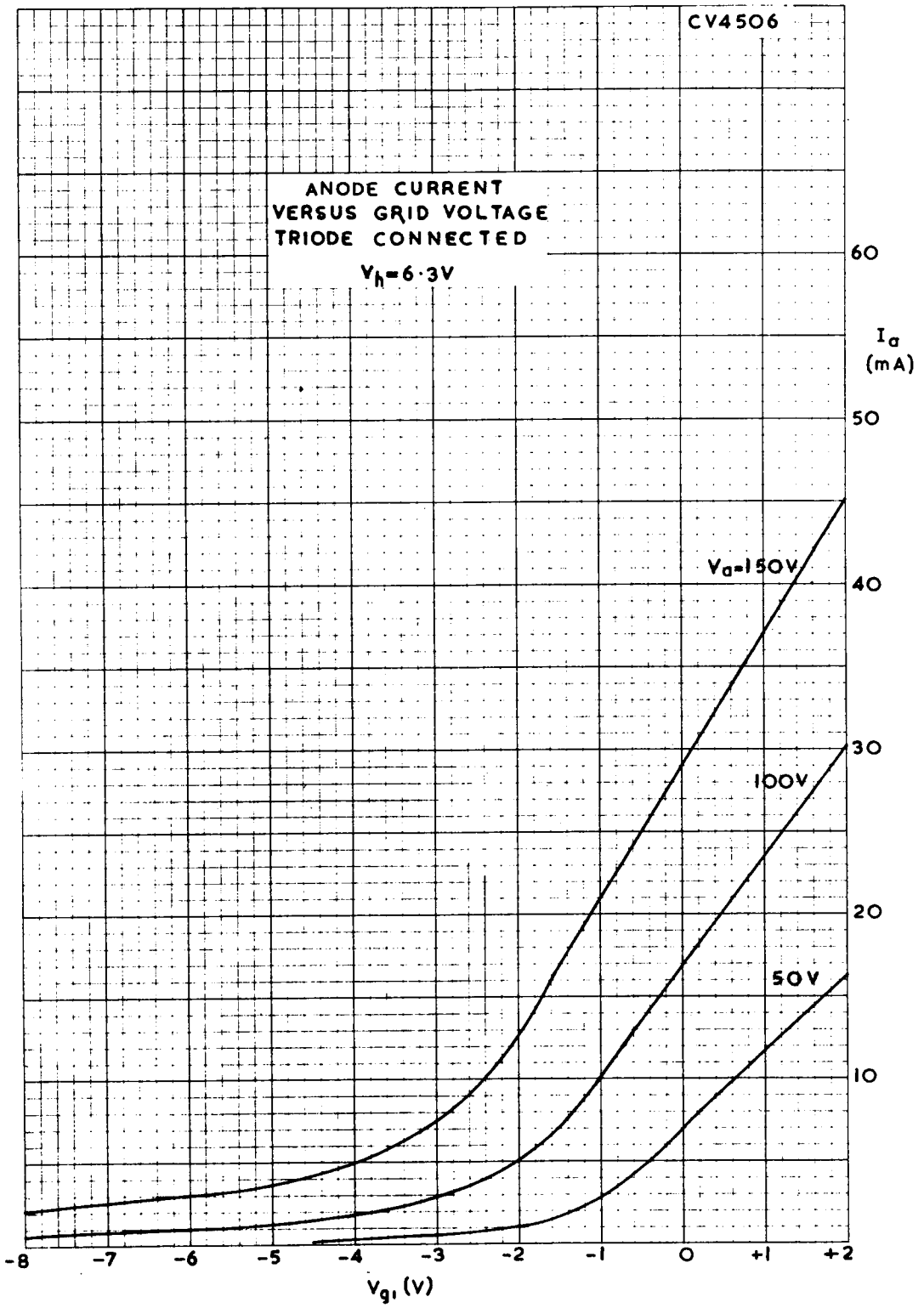
CV4506


CV4506
ANODE & SCREEN CURRENT
VERSUS ANODE VOLTAGE
V_{g2}=150V, V_h=6·3V
ANODE CURRENT
SCREEN CURRENT
P_{g2}=0·55W
P_a=1·1W
V_g=+2V
+1V
0V
−1V
−2V
+2V
+1V
−3V
0V
−4V
−1V
−5V
−6V
−2V
−3V
−4V
I_a, I_{g2} (mA)
V_a (V)
0
100
200
300
400
5
10
15
20
25
30
35

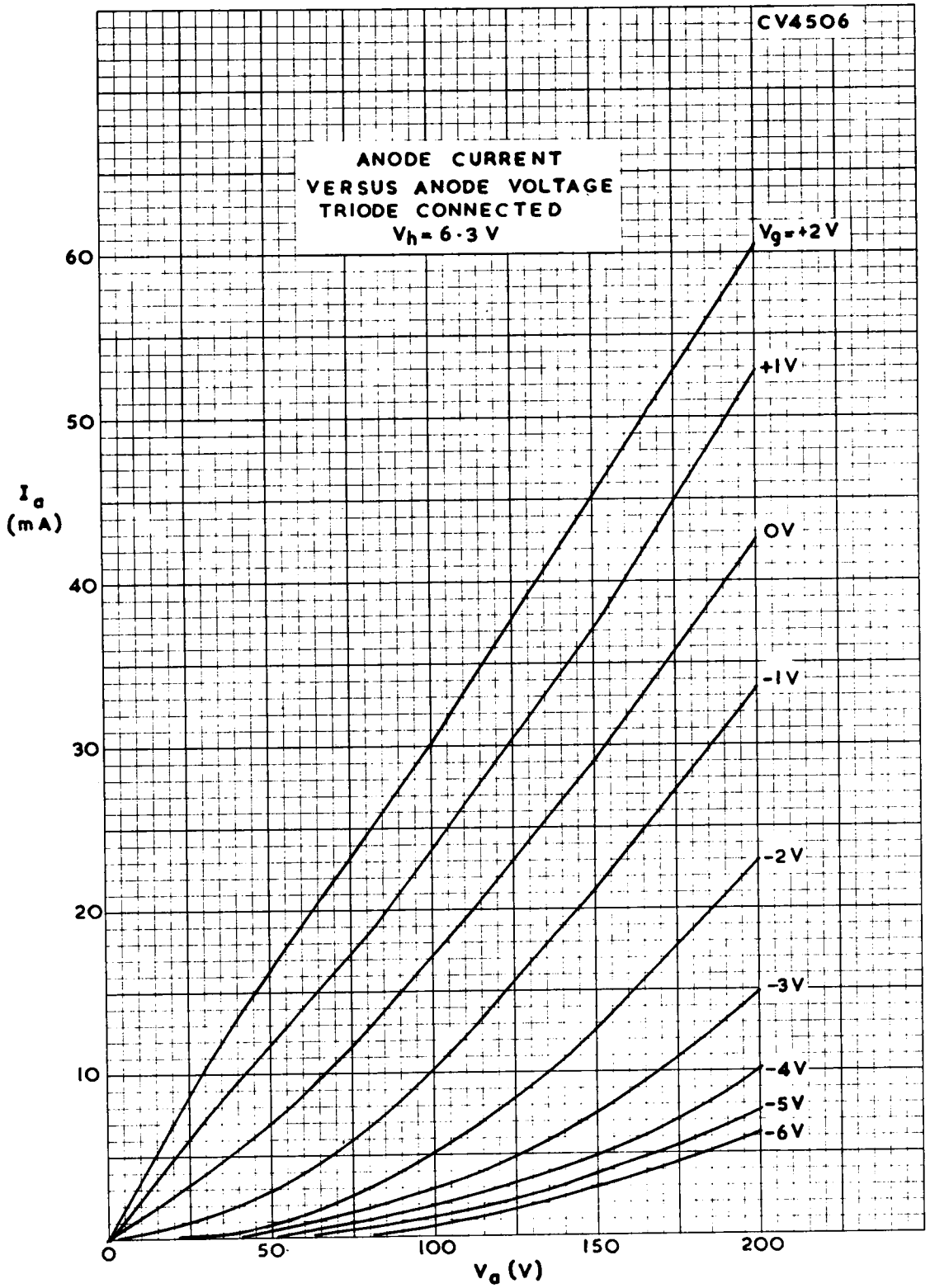

CV4506
ANODE & SCREEN CURRENT
VERSUS ANODE VOLTAGE
FOR A BOTTOM LIMIT VALVE
V_{g2}=150V , V_h=6·3 V
ANODE CURRENT
SCREEN CURRENT
P_{g2}=0·55W
P_a=1·1W
V_{g1}=0V
-1V
-2V
-3V
-4V
-5V
-6V
0V
-1V
-2V
-3V
-4V
I_a , I_{g2} (mA)
V_a (V)
0
100
200
300
400
5
10
15
20
25
30

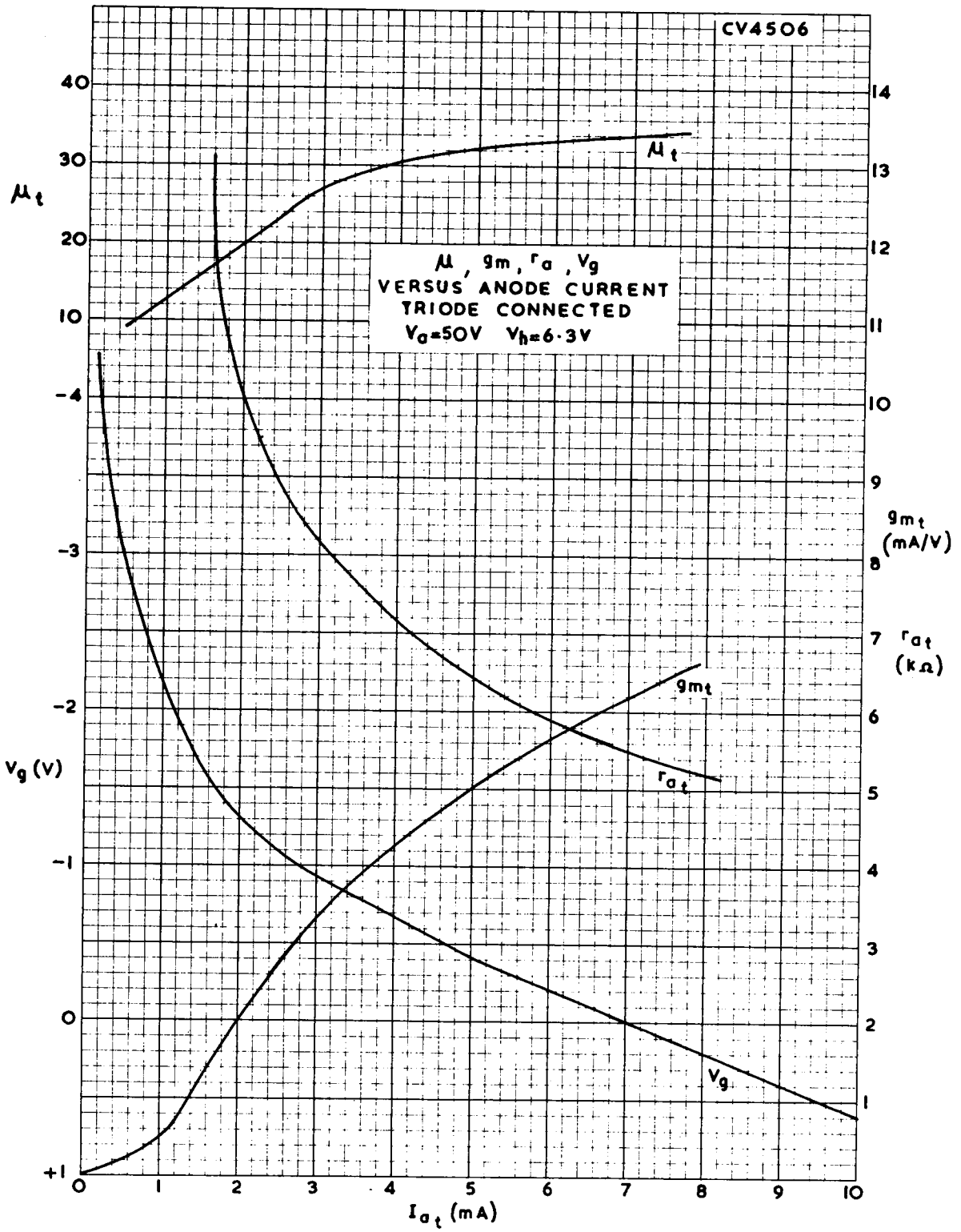
CV4506


CV4506
ANODE & SCREEN CURRENT
VERSUS ANODE VOLTAGE
FOR A TOP LIMIT VALVE
V_{g2}=150V , V_h=6·3 V
ANODE CURRENT
SCREEN CURRENT
P_{g2}=0·55W
P_a=1·1W
V_{g1}=0V
-1V
-2V
-3V
0V
-1V
-4V
-2V
-5V
-6V
-3V
-7V
-4V
-5V
I_a , I_{g2} (mA)
30
25
20
15
10
5
0
100
200
300
400
V_a (V)

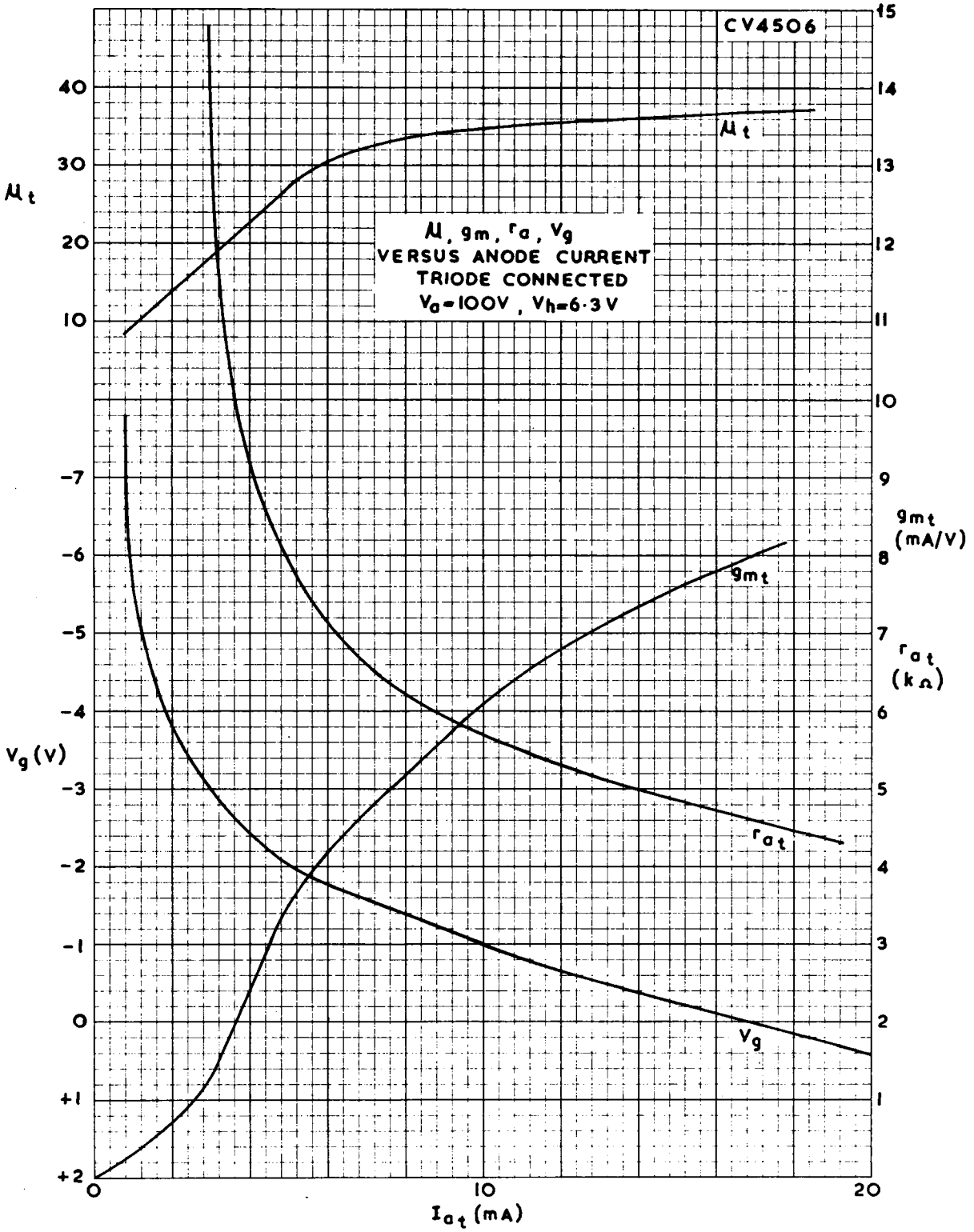

CV4506
ANODE CURRENT
VERSUS GRID VOLTAGE
TRIODE CONNECTED
V_h=6·3V
I_a (mA)
60
50
40
30
20
10
V_a=150V
100V
50V
-8
-7
-6
-5
-4
-3
-2
-1
0
+1
+2
V_{g1} (V)

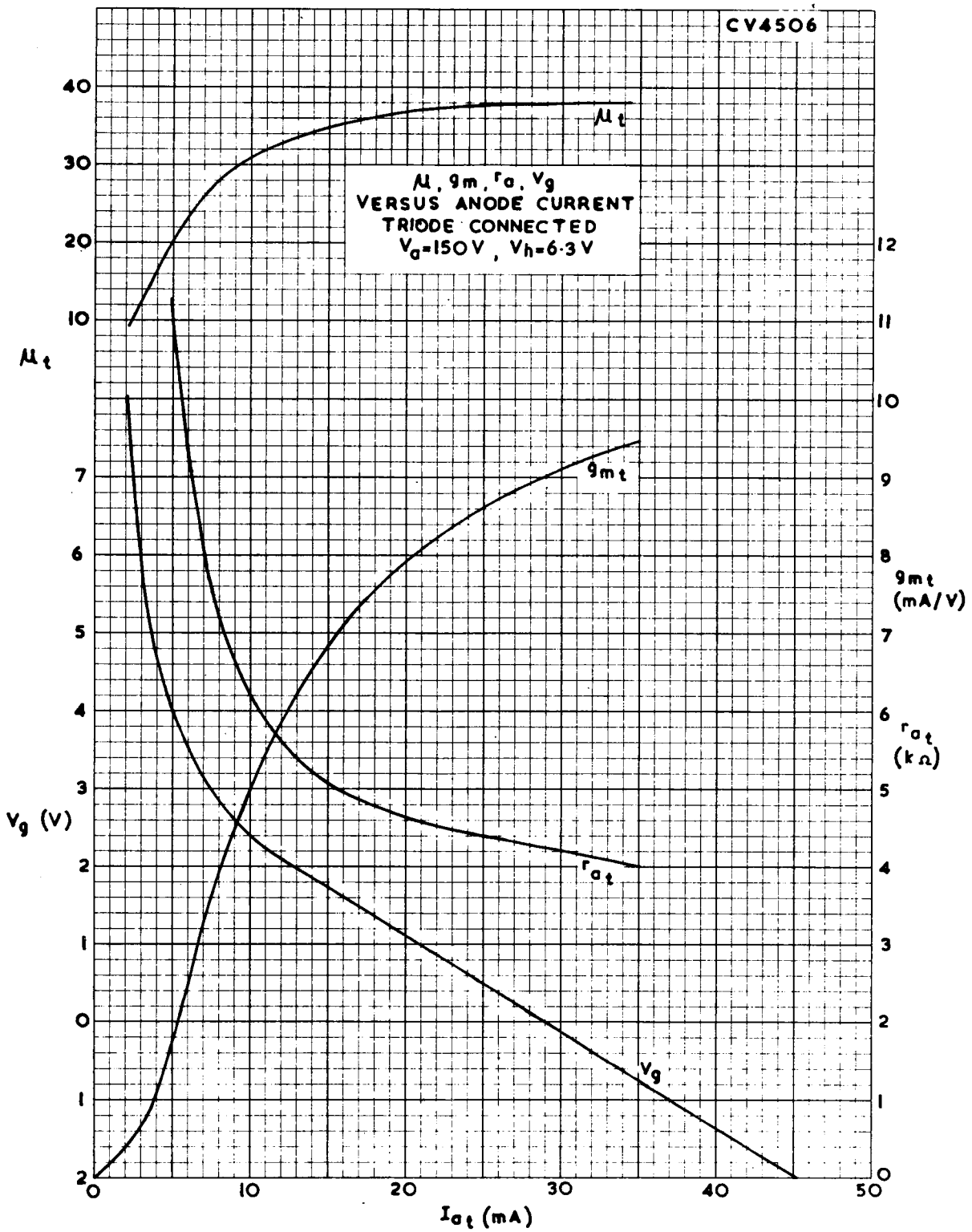
CV4506


CV4506
ANODE CURRENT
VERSUS ANODE VOLTAGE
TRIODE CONNECTED
V_h = 6·3 V
V_g = +2 V
+1 V
0 V
-1 V
-2 V
-3 V
-4 V
-5 V
-6 V
I_a (mA)
60
50
40
30
20
10
0
50
100
150
200
V_a (V)

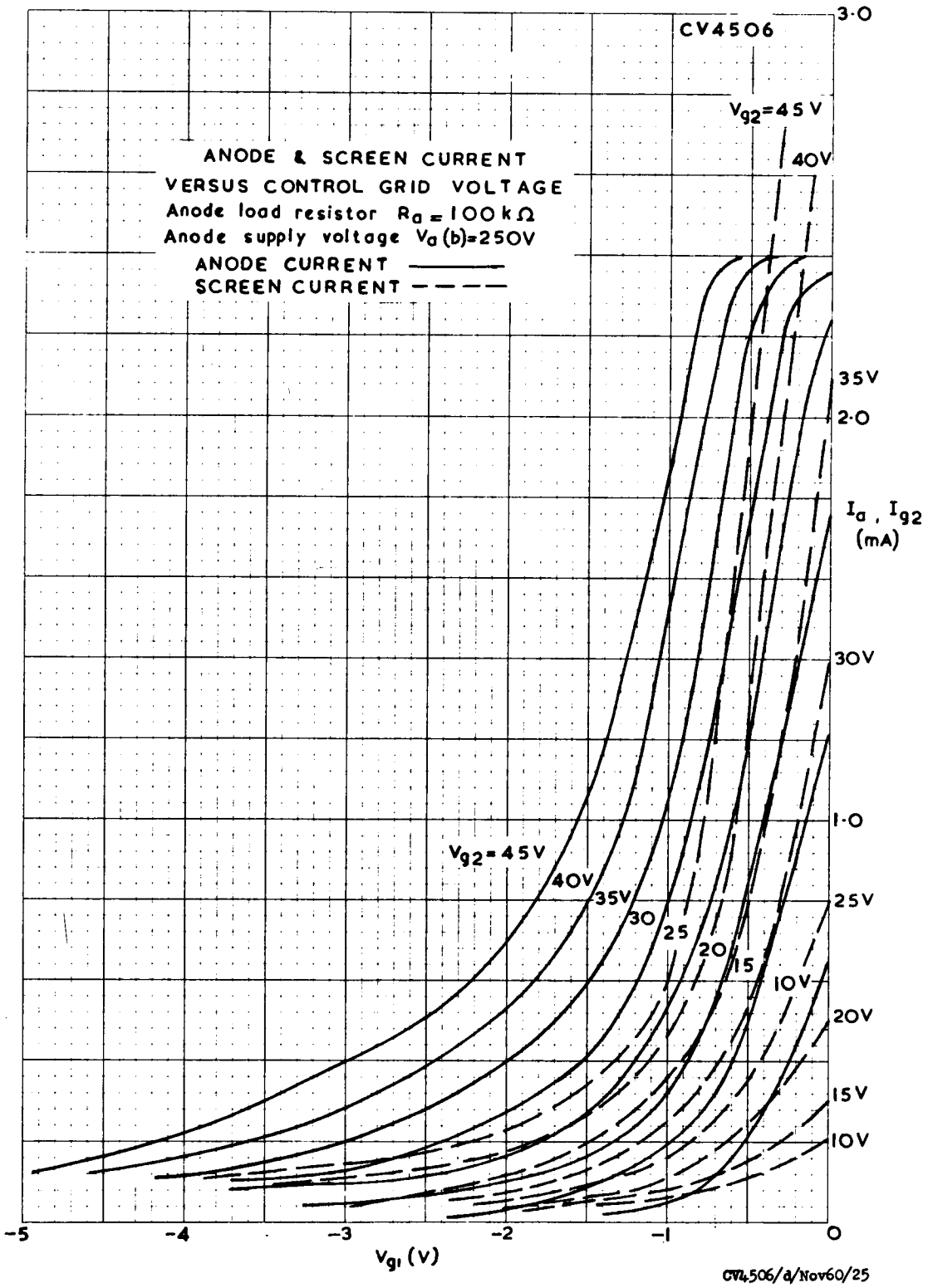

CV4506
μ, gm, ra, Vg
VERSUS ANODE CURRENT
TRIODE CONNECTED
Va=50V Vh=6·3V
μt
gmt
rat
Vg
μt
Vg (V)
gmt (mA/V)
rat (kΩ)
Iat (mA)
40
30
20
10
-4
-3
-2
-1
0
+1
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
9
10

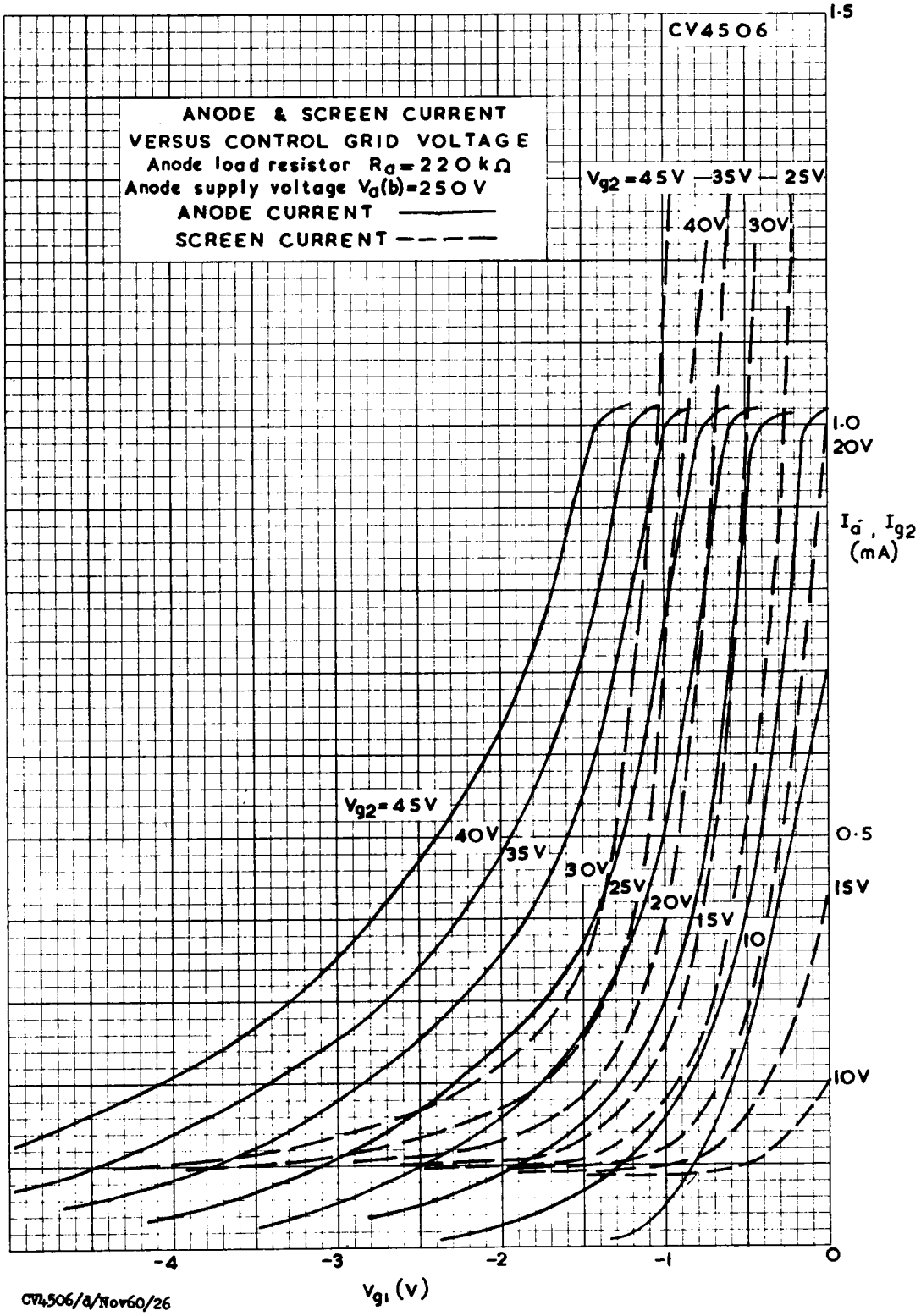
CV4506


CV4506
μ, gm, ra, Vg
VERSUS ANODE CURRENT
TRIODE CONNECTED
Va=100V, Vh=6·3V
μt
gmt
rat
Vg
μt
Vg (V)
gmt (mA/V)
rat (kΩ)
Iat (mA)
40
30
20
10
-7
-6
-5
-4
-3
-2
-1
0
+1
+2
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
10
20

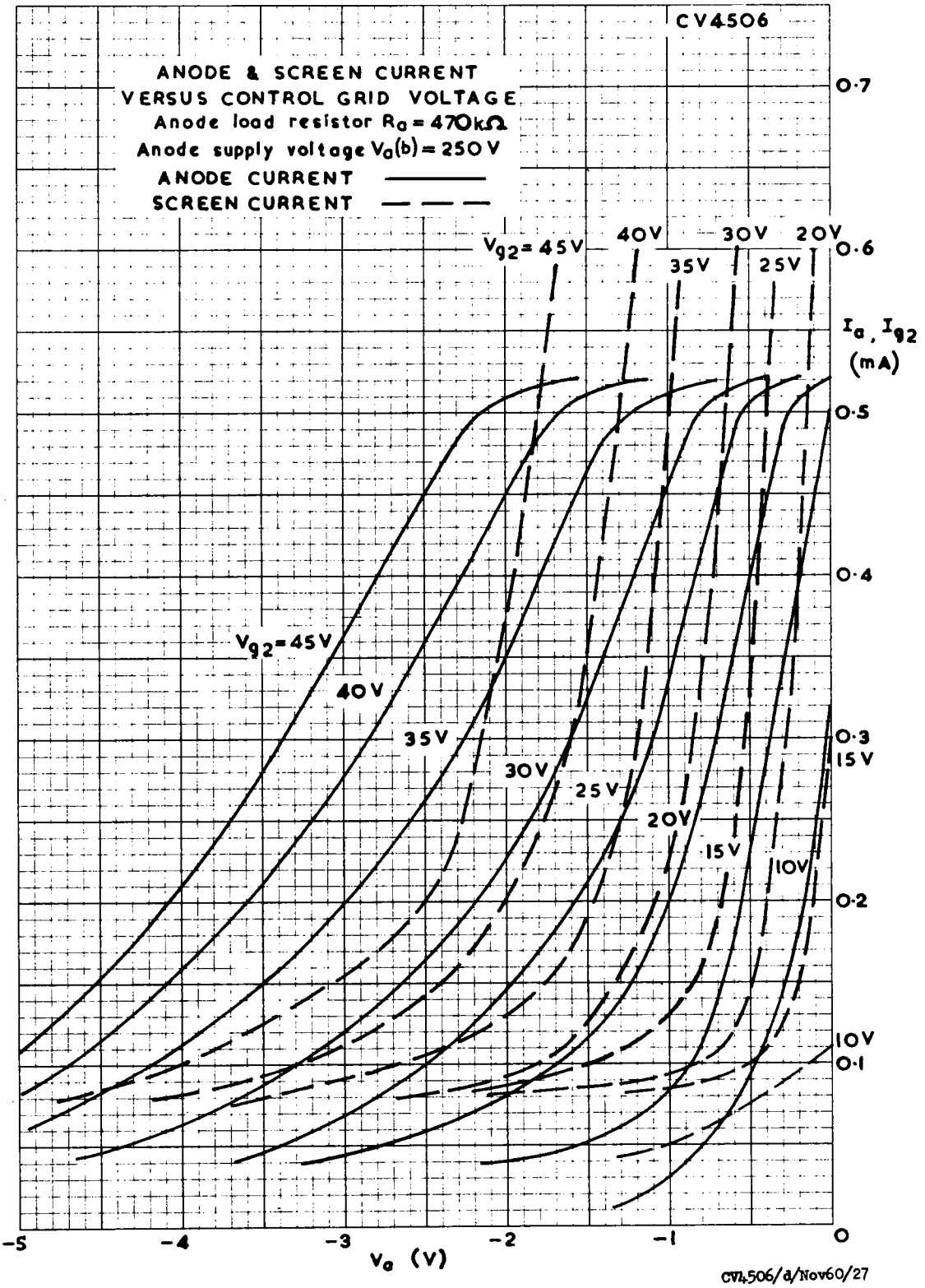

CV4506
μ, gm, ra, Vg
VERSUS ANODE CURRENT
TRIODE CONNECTED
Va=150V, Vh=6·3V
μt
gmt
rat
Vg
μt
Vg (V)
gmt (mA/V)
rat (kΩ)
Iat (mA)
40
30
20
10
7
6
5
4
3
2
1
0
1
2
12
11
10
9
8
7
6
5
4
3
2
1
0
0
10
20
30
40
50

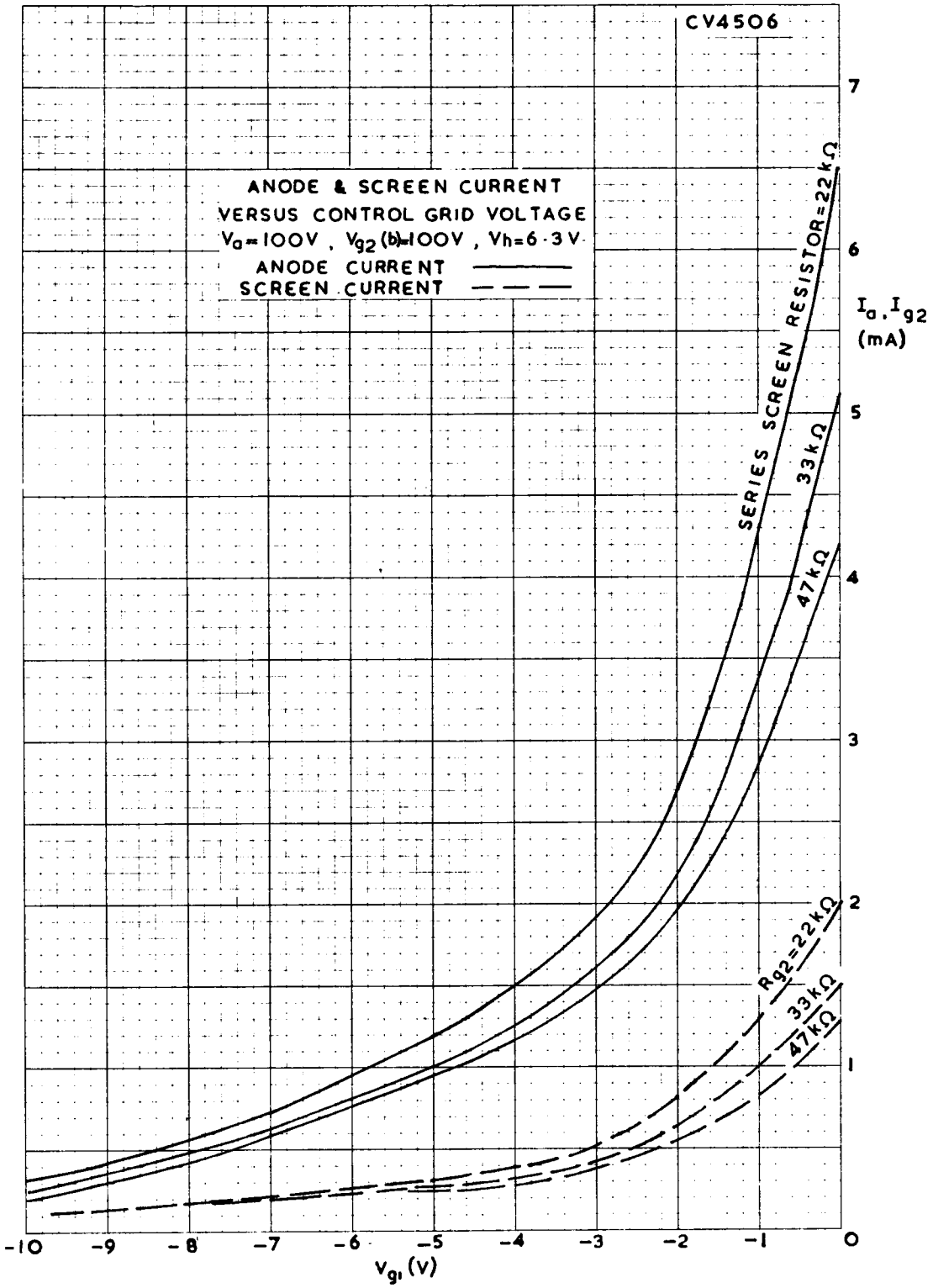
CV4506


CV4506
ANODE & SCREEN CURRENT
VERSUS CONTROL GRID VOLTAGE
Anode load resistor Ra = 100kΩ
Anode supply voltage Va(b)=250V
ANODE CURRENT
SCREEN CURRENT
Vg2=45V
40V
35V
30
25
20
15
10V
3·0
2·0
1·0
45V
40V
35V
30V
25V
20V
15V
10V
Ia , Ig2 (mA)
-5
-4
-3
-2
-1
0
Vg1 (V)

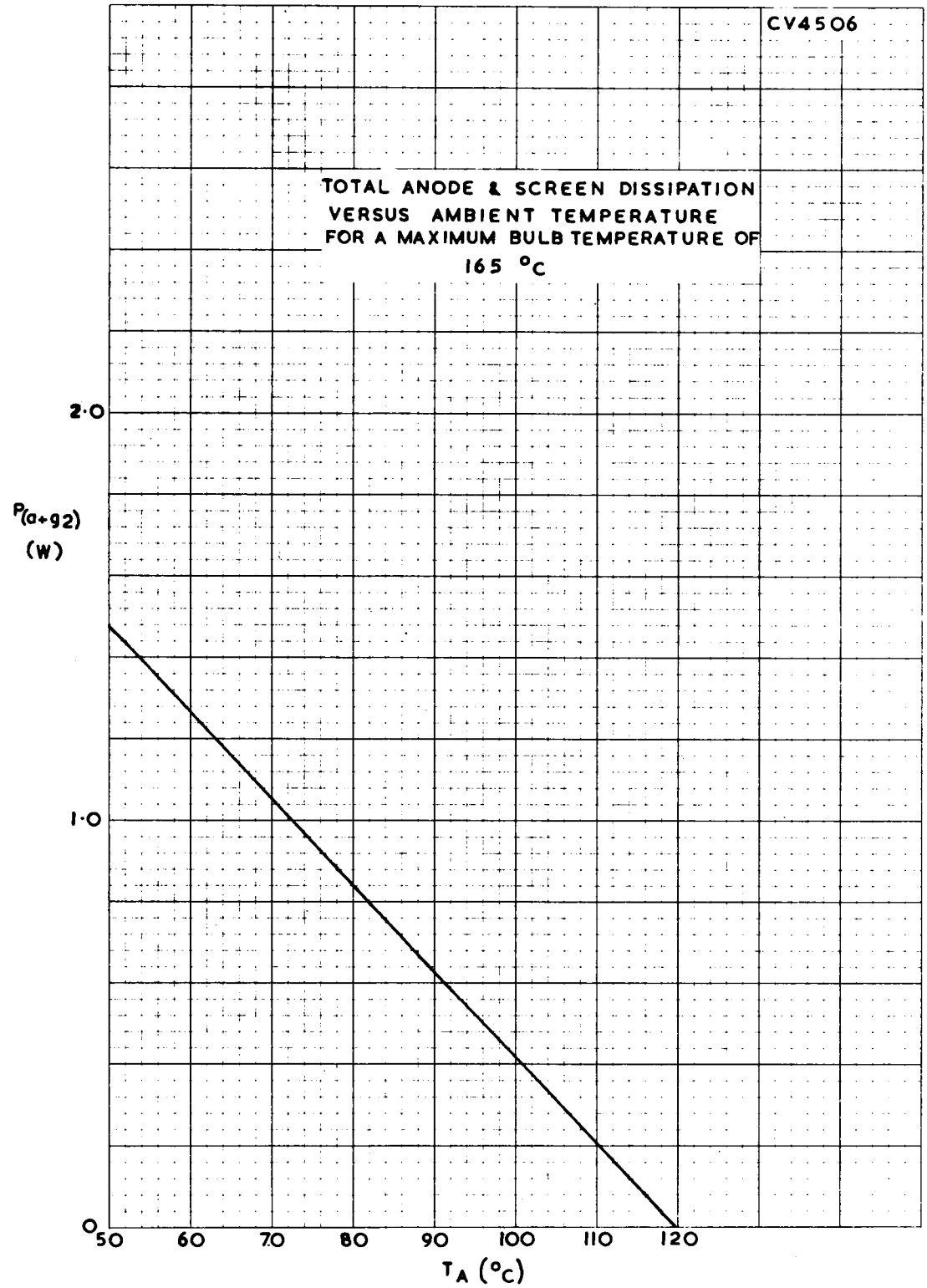

CV4506
ANODE & SCREEN CURRENT
VERSUS CONTROL GRID VOLTAGE
Anode load resistor R_a=220kΩ
Anode supply voltage V_a(b)=250V
ANODE CURRENT
SCREEN CURRENT
V_{g2}=45V 35V 25V
40V 30V
20V
15V
10V
V_{g2}=45V
40V
35V
30V
25V
20V
15V
10
1·5
1·0
0·5
0
I_a, I_{g2} (mA)
-4
-3
-2
-1
V_{g1} (V)

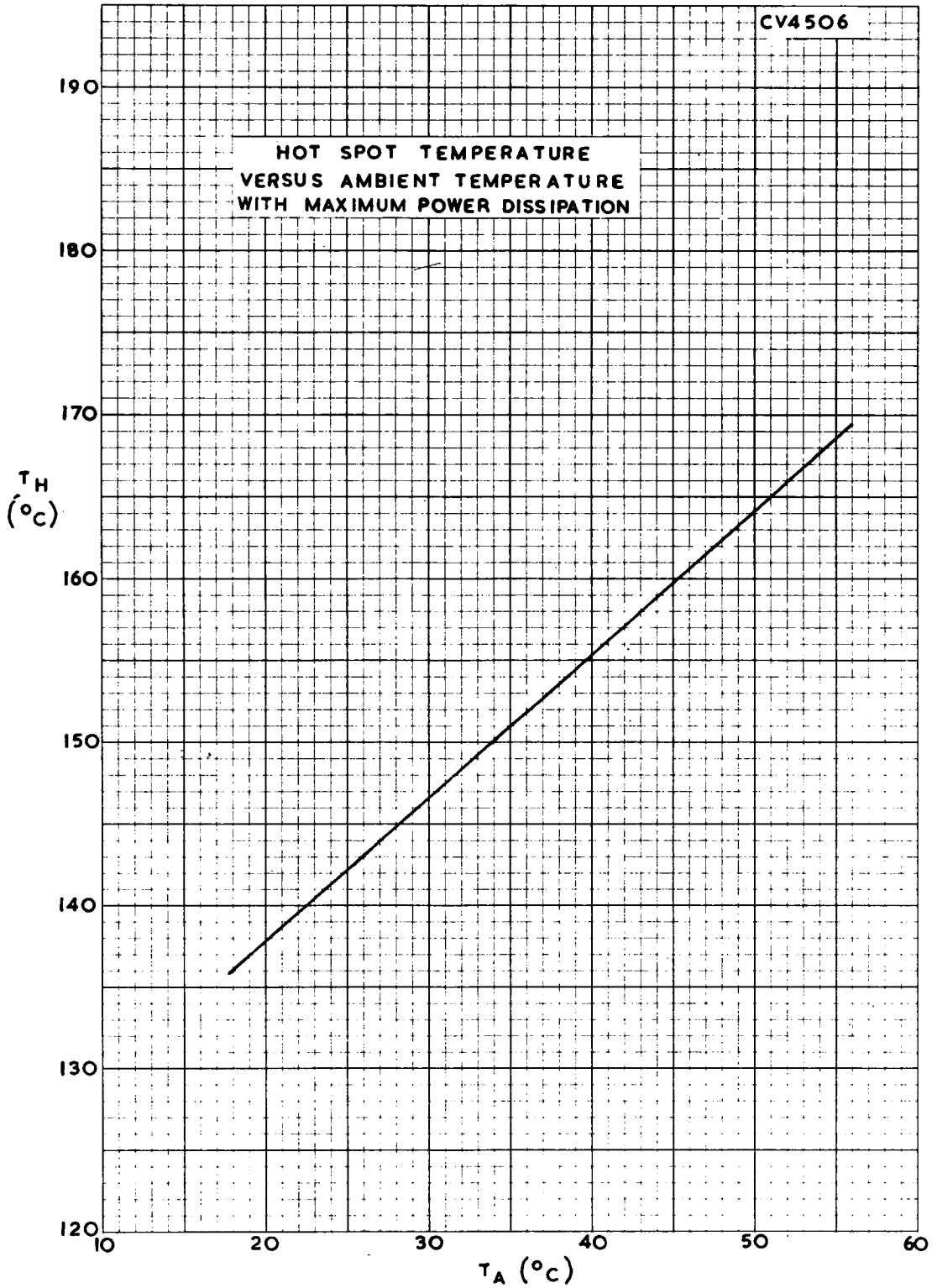
CV4506


CV4506
ANODE & SCREEN CURRENT
VERSUS CONTROL GRID VOLTAGE
Anode load resistor Ra = 470kΩ
Anode supply voltage Va(b) = 250 V
ANODE CURRENT
SCREEN CURRENT
Vg2 = 45V
40V
35V
30V
25V
20V
15V
10V
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0
Ia, Ig2 (mA)
-5
-4
-3
-2
-1
Va (V)


CV4506
ANODE & SCREEN CURRENT
VERSUS CONTROL GRID VOLTAGE
Va=100V , Vg2(b)=100V , Vh=6·3V
ANODE CURRENT
SCREEN CURRENT
SERIES SCREEN RESISTOR=22kΩ
33kΩ
47kΩ
Rg2=22kΩ
33kΩ
47kΩ
Ia, Ig2 (mA)
Vg1 (V)
0
1
2
3
4
5
6
7
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1

CV4506


CV4506
TOTAL ANODE & SCREEN DISSIPATION
VERSUS AMBIENT TEMPERATURE
FOR A MAXIMUM BULB TEMPERATURE OF
165 °C
P(a+g2)
(W)
2·0
1·0
0
50
60
70
80
90
100
110
120
TA (°C)


CV4506
HOT SPOT TEMPERATURE
VERSUS AMBIENT TEMPERATURE
WITH MAXIMUM POWER DISSIPATION
190
180
170
160
150
140
130
120
T_H (°C)
10
20
30
40
50
60
T_A (°C)

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.

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:-

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

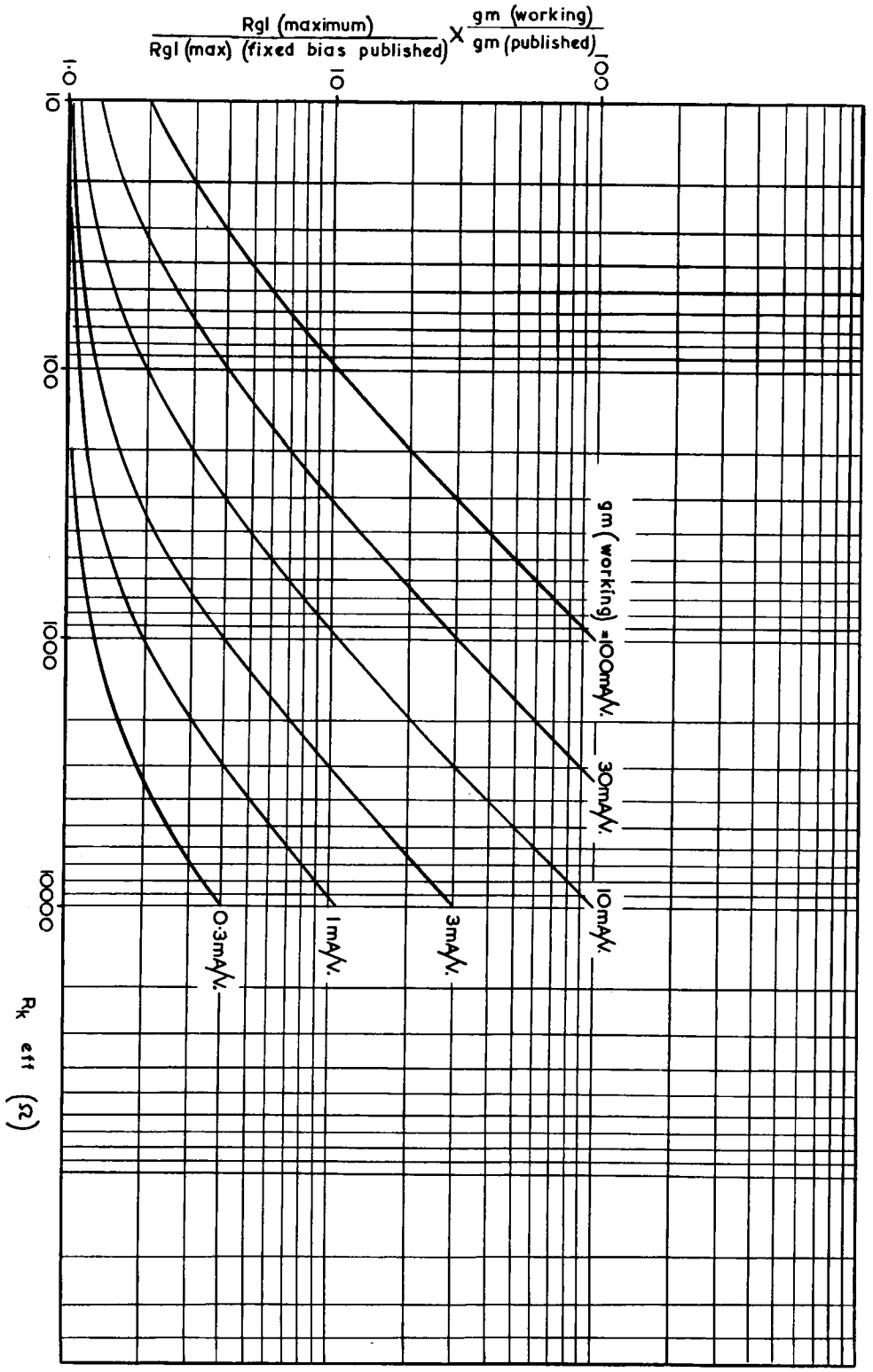
Therefore $$Rg1\ maximum = 16 \times 0.25 \times 10^6 \times \frac{5.2}{3.5} = 6M.$$

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.

CV4506


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