THE M-O VALVE
COMPANY LIMITED

TT21 TT22

G.E.C.

BEAM TETRODES

BRIEF DATA

Beam tetrodes suitable for use as r.f. power amplifiers in single side-band or Class C service, as audio amplifiers or modulators. They are also useful as pulse modulators and in series and shunt stabiliser service.

P_{load} (SSB)	110	W
P_{load} (Class C)	146	W
P_{load} (Audio, per pair)	140	W

HEATER

	TT21	TT22	
V_h	6.3	12.6	V
I_h (approx)	1.6	0.8	A

MAXIMUM RATINGS (Absolute)

	*CCS	†ICAS	
V_a	1.25	1.25	kV
V_a (I_a = 0)	3.5	3.5	kV
V_{g2}	600	600	V
V_{g1}	200	200	V
p_a	37.5	45	W
p_{g2}	6	6	W
p_{g1}	2	2	W
I_k	230	230	mA
$i_{k\,(pk)}$ (r.f.)	2	2	A
$i_{a\,(pk)}$ (pulse)	7.5	7.5	A
V_{h-k}	150	150	V
R_{g1-k} (fixed bias)	100	100	kΩ
R_{g1-k} (cathode bias)	220	220	kΩ
T_{bulb}	250	250	°C

*Continuous Commercial Service is defined as that type of service in which long life and reliability of performance under continuous operating conditions are the prime considerations.

†Intermittent Commercial and Amateur Service is defined as that type of service where minimum size, lightweight and maximum power output are more important than long life.

Intermittent operation implies that no 'on' period exceeds 5 minutes and an 'on' period is followed by an 'off' period of the same or longer duration.

CAPACITANCES

C_{a-g1}	0.25	pF
$C_{a-all\ less\ g1}$	13.5	pF
$C_{g1-all\ less\ a}$	17	pF

CHARACTERISTICS

V_a	250	V
V_{g2}	250	V
I_a	140	mA
g_m	11	mA/V
r_a	12	kΩ
μ_{g1-g2}	8	

OPERATING DATA

A.F. Power Amplifier – Class AB1

The TT21 may be used as an alternative to the KT88 in existing audio designs and the following conditions are typical.

Push–Pull. Cathode Bias. Tetrode Connection.

$V_{a(b)}$	560	V
$V_{a(o)}$	521	V
V_{g2}	300	V
$I_{a(o)}$	2 x 64	mA
$I_{a\ (max\ sig)}$	2 x 73	mA
$I_{g2(o)}$	2 x 1.7	mA
$I_{g2\ (max\ sig)}$	2 x 9	mA

$R_{load\ (a-a)}$	9	kΩ
*R_k	2 x 460	Ω
$-V_{g1}$ (approx)	30	V
P_{out}	50	W
D_{tot}	3	%
†IM	11	%
$p_{a(o)}$	2 x 33	W
p_a (max sig)	2 x 12	W
$p_{g2(o)}$	2 x 0.5	W
p_{g2} (max sig)	2 x 2.7	W
$V_{g1(ac)}$ (pk)	2 x 30	V

*It is essential to use two separate cathode bias resistors.
†Intermodulation distortion; measured using two input signals at 50 and 6000Hz (ratio of amplitudes 4:1).

Push–Pull. Fixed Bias. Tetrode Connection.

$V_{a(b)}$	560	V
$V_{a(o)}$	552	V
V_{g2}	300	V
$I_{a(o)}$	2 x 60	mA
I_a (max sig)	2 x 145	mA
$I_{g2(o)}$	2 x 1.7	mA
I_{g2} (max sig)	2 x 15	mA
$R_{load\ (a-a)}$	4.5	kΩ
*$-V_{g1}$ (approx)	34	V
P_{out}	100	W
D_{tot}	2.5	%
†IM	10	%
$p_{a(o)}$	2 x 33	W
p_a (max sig)	2 x 28	W
$p_{g2(o)}$	2 x 0.5	W
p_{g2} (max sig)	2 x 4.5	W
$V_{g1(ac)}$ (pk)	2 x 33.5	V

*It is essential to provide two separately adjustable bias voltage sources, having a voltage adjustment range of ±50%.
†Intermodulation distortion; measured using two input signals at 50 and 6000Hz (ratio of amplitudes 4:1).

Push–Pull. Cathode Bias. Ultra-Linear Connection (40% Tapping Points).

$V_{a,\ g2(b)}$	500	375	V
$V_{a,\ g2(o)}$	436	328	V
$I_{a+g2(o)}$	2 x 87	2 x 87	mA
$I_{a+g2\ (max\ sig)}$	2 x 99	2 x 96	mA
$R_{load\ (a-a)}$	6	5	kΩ
*R_k	2 x 600	2 x 400	Ω
$-V_{g1}$ (approx)	52	35	V
P_{out}	50	30	W
D_{tot}	1.5	1	%
†IM	4	3	%
$p_{a+g2(o)}$	2 x 38	2 x 28.5	W
$p_{a+g2\ (max\ sig)}$	2 x 17	2 x 16	W
$V_{g1(ac)\ (pk)}$	2 x 52	2 x 35.5	V
Z_{out}	4.8	4.5	kΩ

*It is essential to use two separate cathode bias resistors.
†Intermodulation distortion; measured using two input signals at 50 and 6000Hz (ratio of amplitudes 4:1).

A.F. Power Amplifier and Modulator – Class AB1 – Fixed Bias
(Tetrode Connection)

Maximum Permissible Conditions – CCS

V_a	1.25	kV
V_{g2}	600	V
p_a	37.5	W
p_{g2}	6	W

Typical Operation
Performance in an amplifier at various signal levels.

$V_{a(b)}$	1000	1000	1000	1000	V
V_a	996	993	990	989	V
$V_{g2(b)}$	300	300	300	300	V
V_{g2}	300	300	299	298	V
*$-V_{g1}$ (approx)	40	40	40	40	V
$V_{g1(ac)\ (pk)}$	2 x 0	2 x 16	2 x 25.5	2 x 32	V
I_a	2 x 35	2 x 55	2 x 79	2 x 90	mA
I_{g2}	2 x 0.35	2 x 1.2	2 x 4.5	2 x 11.5	mA
P_{load}	.0	40	100	140	W
$R_{load\ (a-a)}$	16.8	16.8	16.8	16.8	kΩ
D	1.25	1.5	4.8		%

*Must be separately adjusted on each tube with no signal. Bias supply should have an adjustment range of ±50%.

A modulator operating under these conditions is described in Application Report No. 17. It is convenient for use with a TT21 with anode and screen modulation and with the modulator and r.f. stage operating from a common 1000V h.t. supply.

R.F. Power Amplifier – Class C Telegraphy

Maximum Permissible Conditions

	CCS	ICAS	
V_a	1.25	1.25	kV
V_{g2}	600	600	V
$-V_{g1}$	200	200	V
I_a	200	200	mA
p_a	37.5	45	W
P_{in}	200	220	W
p_{g2}	6	6	W
p_{g1}	2	2	W

Typical Operation – CCS

V_a	500	800	1000	1250	V
V_{g2}	300	300	300	300	V
$-V_{g1}$	90	90	90	90	V
I_a	192	182	175	160	mA
I_{g2}	20	20	20	20	mA
I_{g1}	8.5	7	5.5	4.5	mA
p_a	37.5	37.5	37.5	37.5	W
p_{g2}	6	6	6	6	W
P_{out}	58.5	108.5	137.5	162.5	W
Efficiency	61	75	78	81	%
*P_{load}	52	95	115	132	W
$P_{out(driver)}$	2.1	1.9	1.8	1.6	W

*Measured at 30MHz

Typical Operation – ICAS

V_a	500	800	1000	1250	V
V_{g2}	300	300	300	300	V
$-V_{g1}$	90	90	90	90	V
I_a	200	200	190	175	mA
I_{g2}	20	20	20	20	mA
I_{g1}	9	9	7.5	6	mA
p_a	40	43	45	45	W
p_{g2}	6	6	6	6	W
P_{out}	60	117	145	174	W
Efficiency	59	74	76.5	79.5	%
*P_{load}	52	103	126	146	W
P_{out} (driver)	2.1	2.1	2	1.9	W

*Measured at 30MHz.

R.F. Power Amplifier – Class C – Anode and Screen Modulated

Maximum Permissible Conditions

		(Carrier Conditions)	
	CCS	ICAS	
V_a	1	1	kV
V_{g2}	600	600	V
$-V_{g1}$	200	200	V
I_a	160	180	mA
p_a	25	30	W
P_{in}	130	150	W
p_{g2}	6	6	W
p_{g1}	2	2	W
Modulation	100	100	%

Typical Operation – CCS

V_a	550	700	850	1000	V
V_{g2}	300	300	300	300	V
$-V_{g1}$	115	115	115	115	V
I_a	160	150	140	130	mA
I_{g2}	20	20	20	20	mA
I_{g1}	5	3.5	3	2.5	mA
p_a	25	25	25	25	W
p_{g2}	6	6	6	6	W
P_{out}	63.5	80	95	105	W
Efficiency	72	76	80	81	%
*P_{load}	54	70	82	87	W
P_{out} (driver)	1.5	1.4	1.2	1.1	W
P_{mod}	50	60	68	75	W

*Measured at 30MHz.

Typical Operation – ICAS

V_a	550	700	850	1000	V
V_{g2}	300	300	300	300	V
$-V_{g1}$	115	115	115	115	V
I_a	180	175	165	150	mA
I_{g2}	20	20	20	20	mA
I_{g1}	6.5	5.5	5	3.5	mA
p_a	30	30	30	30	W
p_{g2}	6	6	6	6	W
P_{out}	69	92	110	123	W
Efficiency	70	75.5	78.5	82	%
*P_{load}	61	82	94	101	W
P_{out} (driver)	1.8	1.7	1.5	1.2	W
P_{mod}	55	68	80	85	W

*Measured at 30MHz.

R.F. Power Amplifier – Class AB1 – SSB

Maximum Permissible Conditions

	CCS	ICAS	
V_a	1.25	1.25	kV
V_{g2}	600	600	V
$-V_{g1}$	200	200	V
p_a	37.5	45	W
p_{g2}	6	6	W
p_{g1}	2	2	W

Typical Operation

	CCS	CCS	ICAS†	
V_a	800	1000	1200	V
V_{g2}	300	300	300	V
*$-V_{g1}$	38	40	45	V
$V_{g1(ac)\ (pk)}$	37	39	44	V
$I_{a(o)}$	40	37.5	32.5	mA
$I_{g2(o)}$	0.5	0.3	–	mA
$p_{a(o)}$	32	37.5	39	W

	2-tone	1-tone	2-tone	1-tone	2-tone	1-tone	
$I_{a(max\ sig)}$	86	122	83	130	90	136	mA
$I_{g2(max\ sig)}$	4.5	11	5	9	4	8	mA
$I_{g1(max\ sig)}$	0	0	0	0	0	0	
$p_{a(max\ sig)}$	33.5	26.5	34.5	33	47	41	W
$p_{g2(max\ sig)}$	1.4	3.3	1.5	2.7	1.2	2.4	W
$P_{out(mean)}$	35.5	71	48.5	97	61	122	W
PEP_{out}	71	–	97	–	122	–	W
Z_a	4	4	4.8	4.8	5.5	5.5	kΩ
$P_{load(mean)}$	32	64	43.75	87.5	55	110	W
PEP_{load}	64	–	87.5	–	110	–	W
‡D_3	36	–	33	–	29	–	dB
‡D_5	49	–	46	–	43	–	dB

*Adjust to obtain specified value of $I_{a(o)}$.
†The available output is limited by the anode dissipation under two-tone test conditions. Greater output may be possible if the peak to mean value of the modulation waveforms permit greater input power without exceeding the dissipation rating.
‡Measured with reference to either of the two tones.

A complete linear amplifier is described in Application Report No. 15.

Pulse Modulator Service

Maximum Permissible Conditions

V_a	3.5	kV
V_{g2}	600	V
$-V_{g1}$	200	V
p_a	37.5	W
p_{g2}	6	W
p_{g1}	2	W
$i_{a(pk)}$	7.5	A

Typical Operation

V_a	3.5	kV
V_{g2}	600	V
$-V_{g1}$	150	V
$V_{g1(pulse)}$	380	V
$I_{a(pulse)}$	6	A
$I_{g2(pulse)}$	2.1	A
$I_{g1(pulse)}$	2.3	A
R_a	460	Ω
t_p	2	μs
PRF	1500	p/s

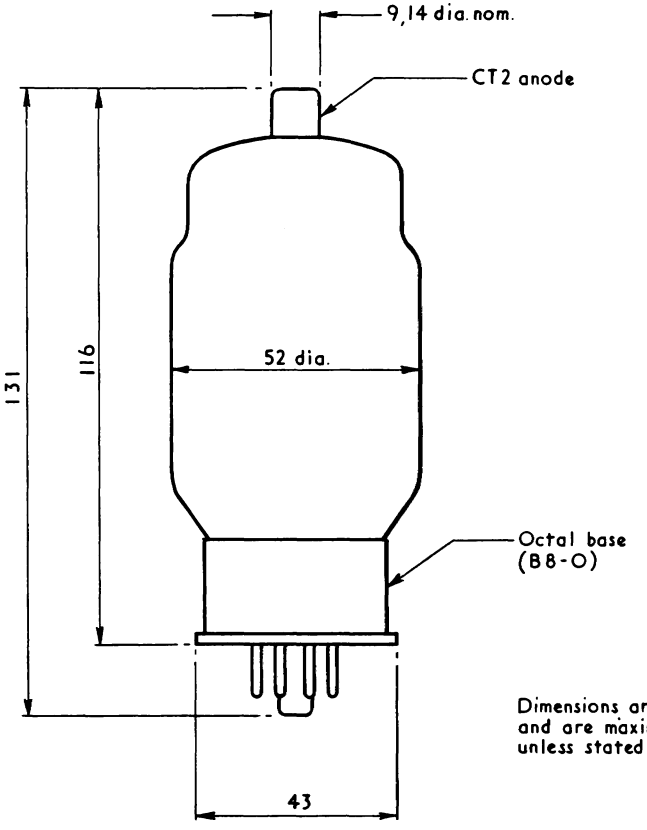
INSTALLATION

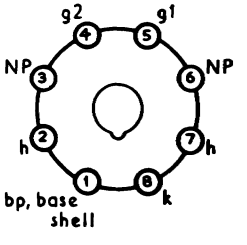
The tube may be mounted either vertically or horizontally. When a pair of tubes is mounted vertically it is recommended that the centres of the tube-holders are not less than 100mm apart and that pins 4 and 8 of each tube are in line. When a pair of tubes is mounted horizontally it is recommended that the centres of the tubeholders are not less than 100mm apart and that pins 4 and 8 of each tube are in the same vertical line. If circuit layout makes closer mounting desirable, free air circulation around the tube must be ensured, if necessary by means of a small fan. The bulb temperature under the worst operating conditions must not exceed 250°C.

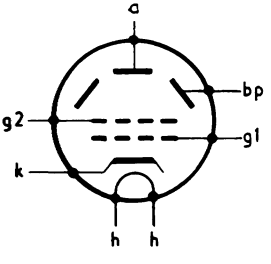
OPERATING NOTES

In order to prevent parasitic oscillation, it is desirable to use a grid stopper resistor mounted close to the tubeholder. In Class AB1 audio circuits this may have a value up to 10kΩ reducing to about 100Ω in r.f. circuits, when an anode stopper consisting of a 100Ω ¼W resistor overwound with 2½ turns of 18 s.w.g. copper wire may also be necessary. The usual practice of using a single chassis point for all earth returns should always be adopted in r.f. equipment.

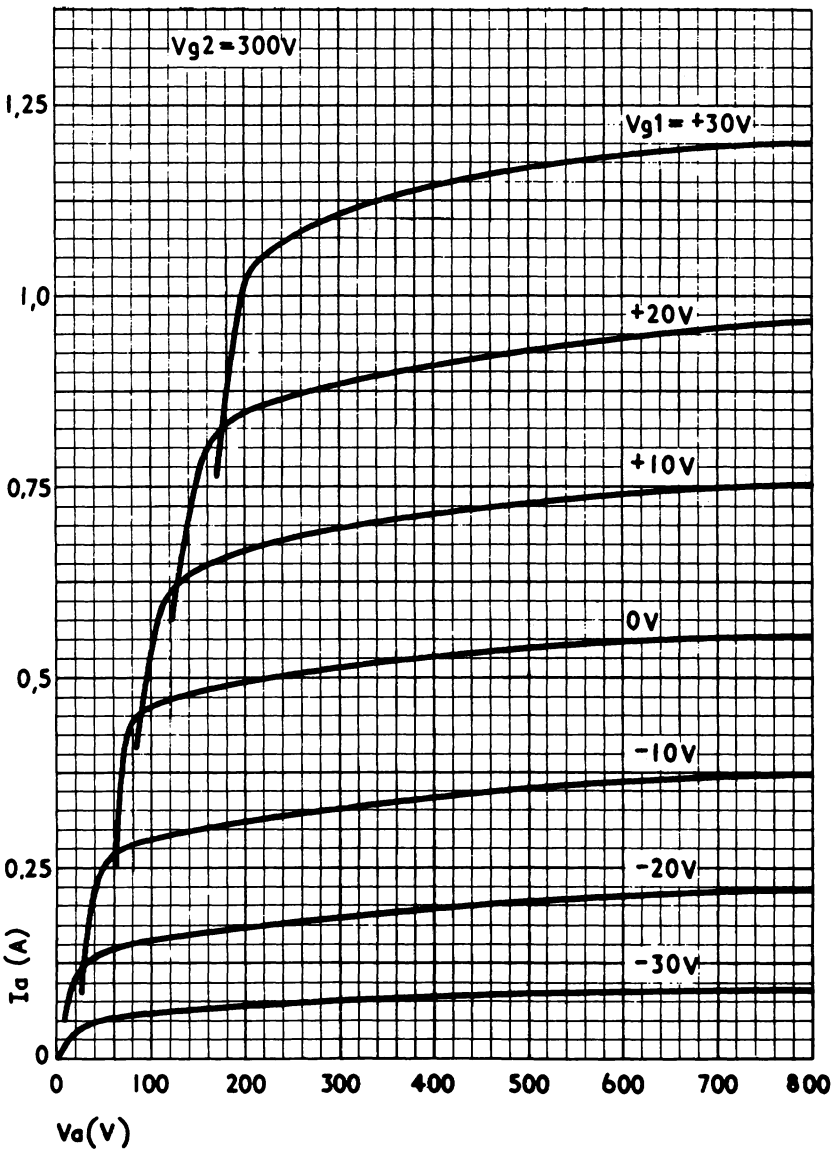
OUTLINE AND BASE CONNECTIONS



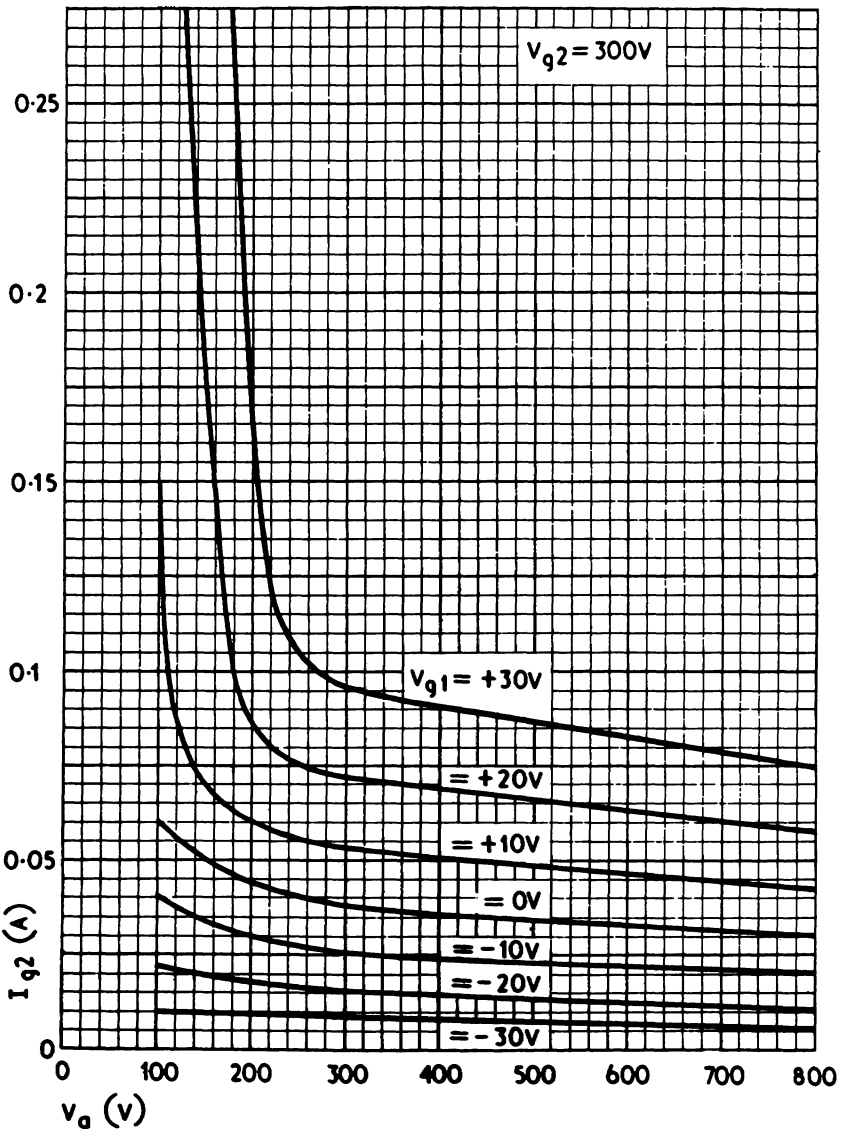




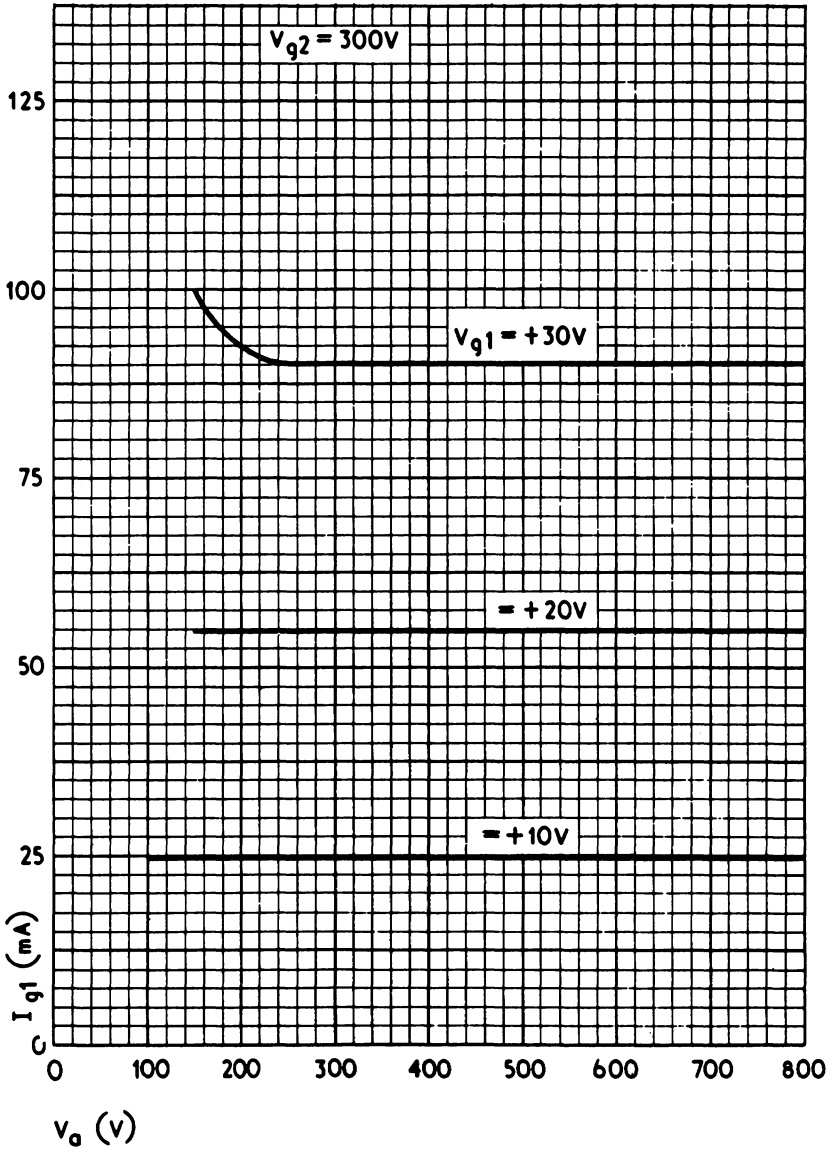
ANODE CURRENT – ANODE VOLTAGE. SCREEN VOLTAGE AT 300V WITH GRID VOLTAGE AS PARAMETER



SCREEN CURRENT – ANODE VOLTAGE. SCREEN VOLTAGE OF 300V WITH GRID VOLTAGE AS PARAMETER



GRID CURRENT – ANODE VOLTAGE. SCREEN VOLTAGE AT 300V WITH POSITIVE GRID VOLTAGE AS PARAMETER



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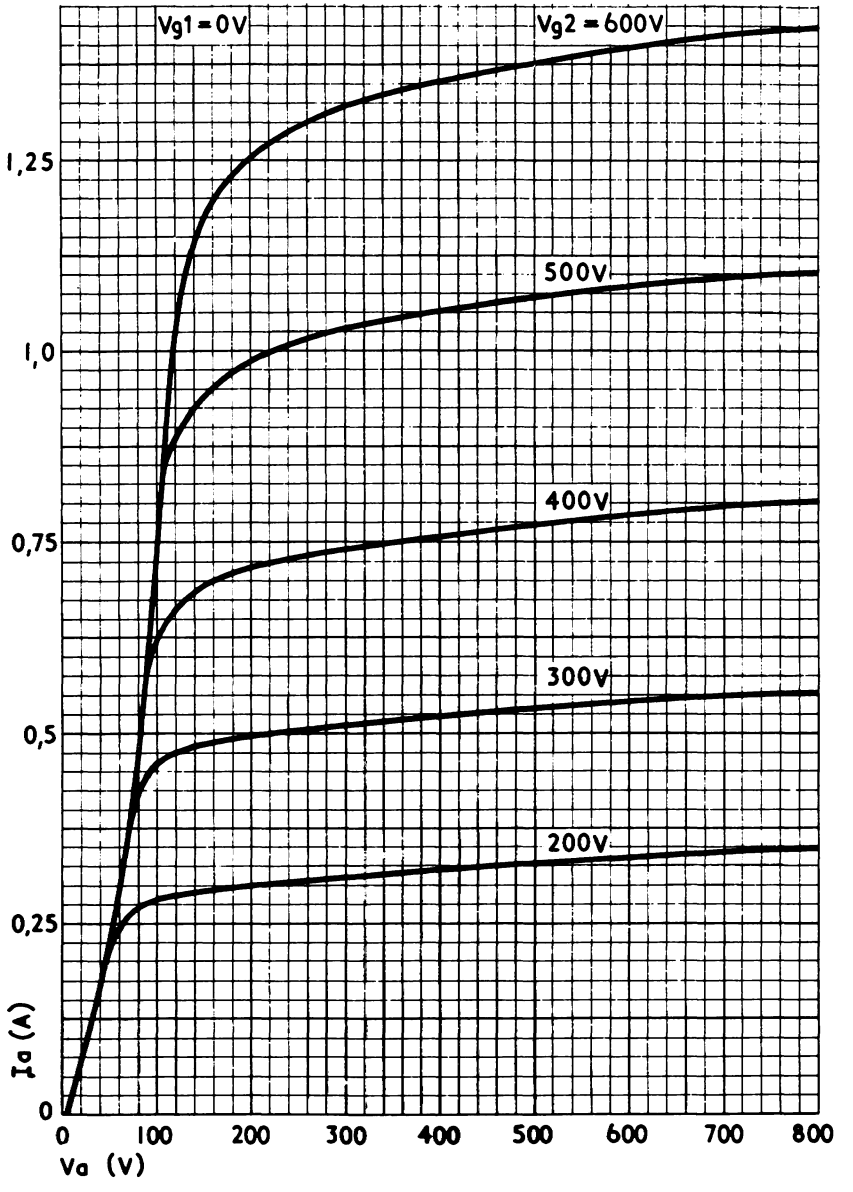

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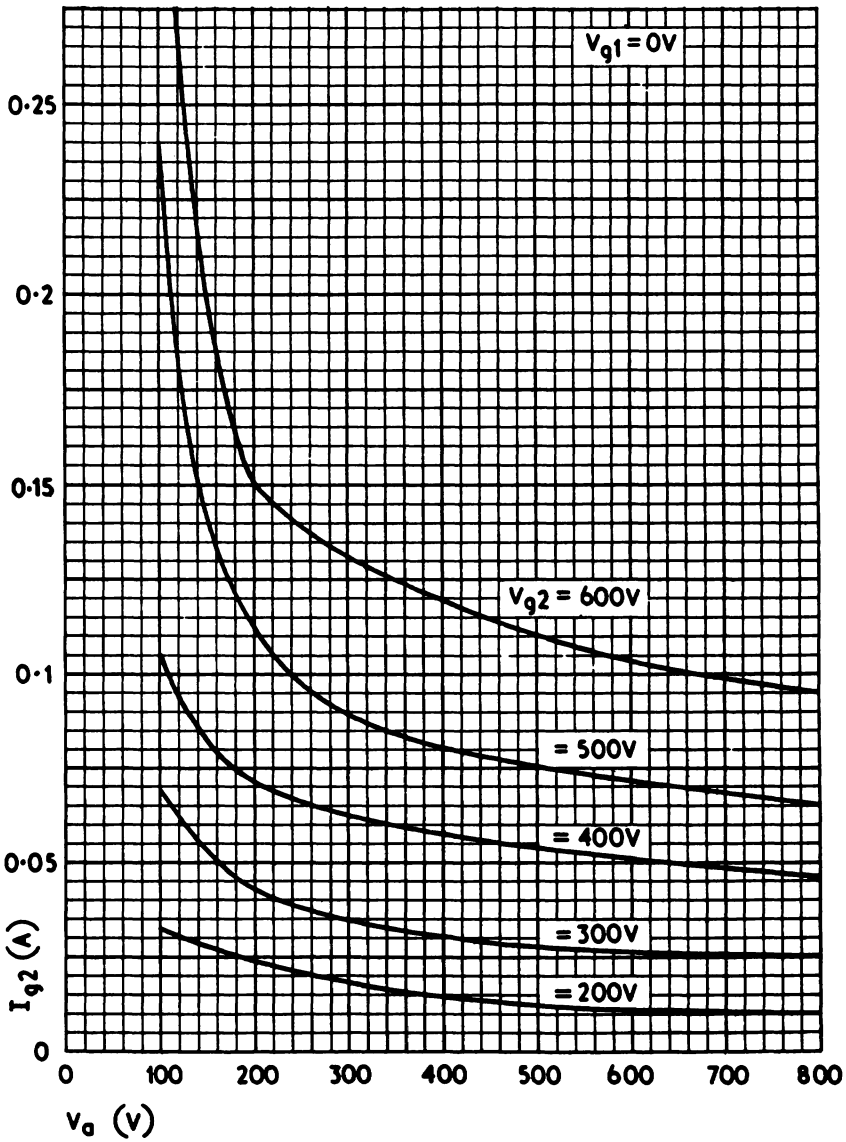
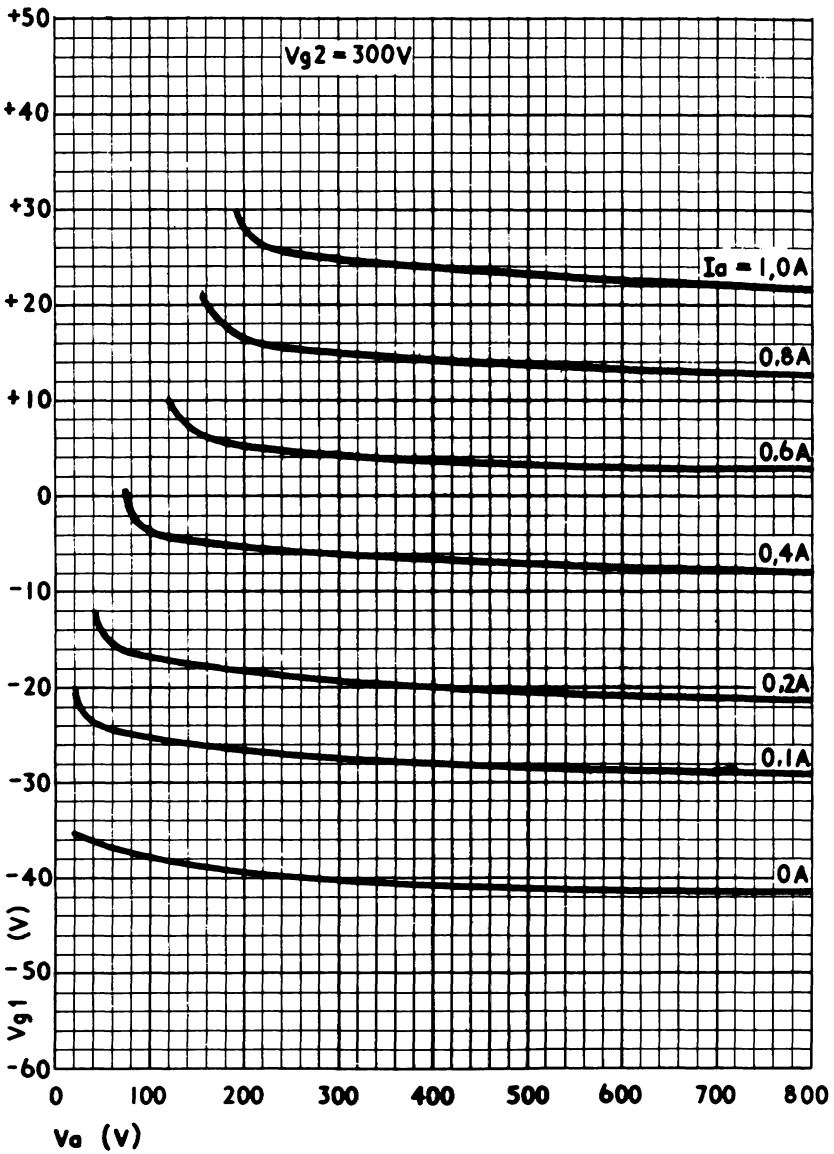


CONSTANT ANODE CURRENT CURVES WITH SCREEN VOLTAGE AT 300V



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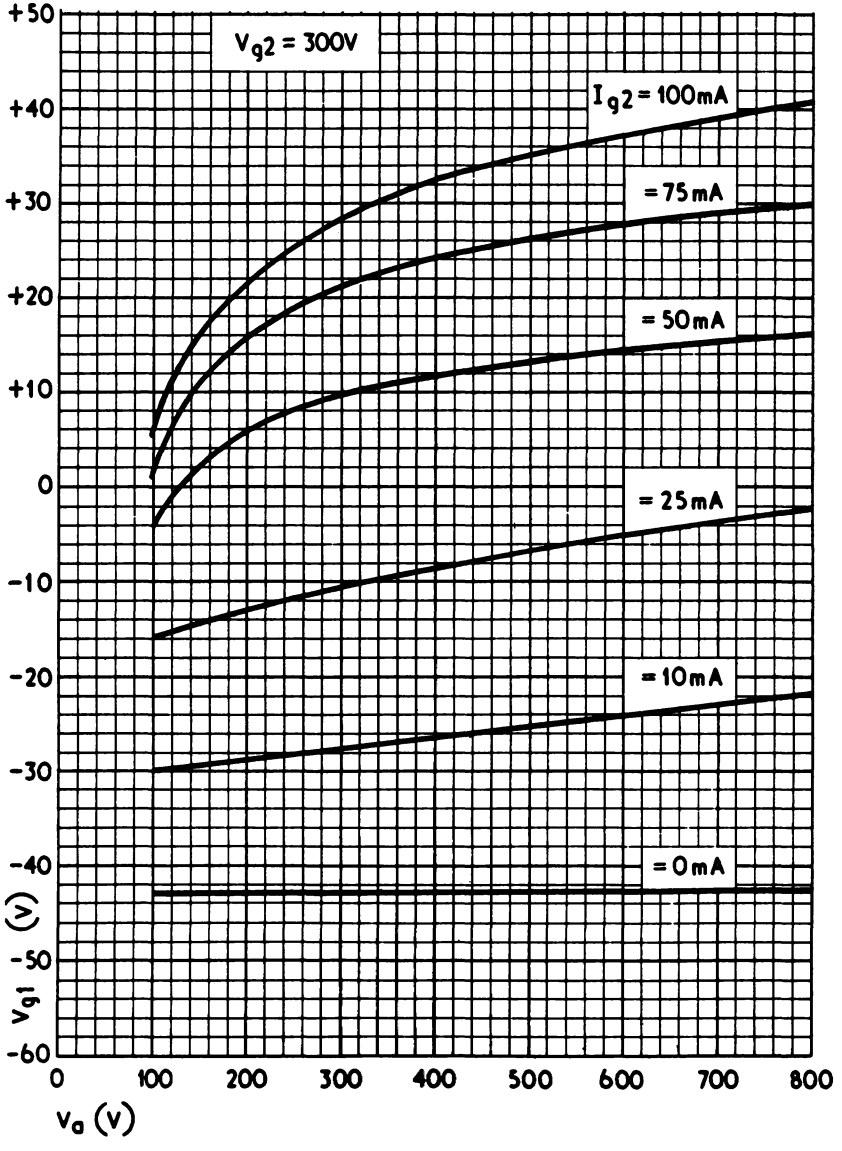

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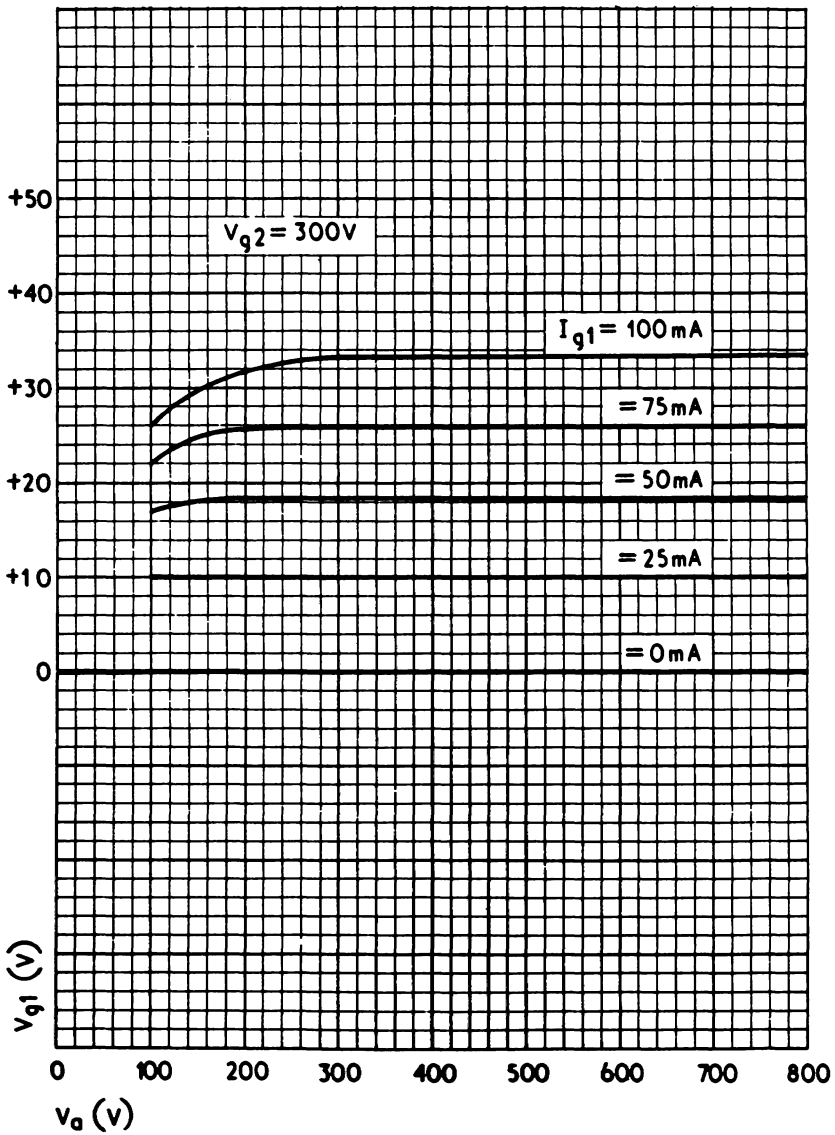

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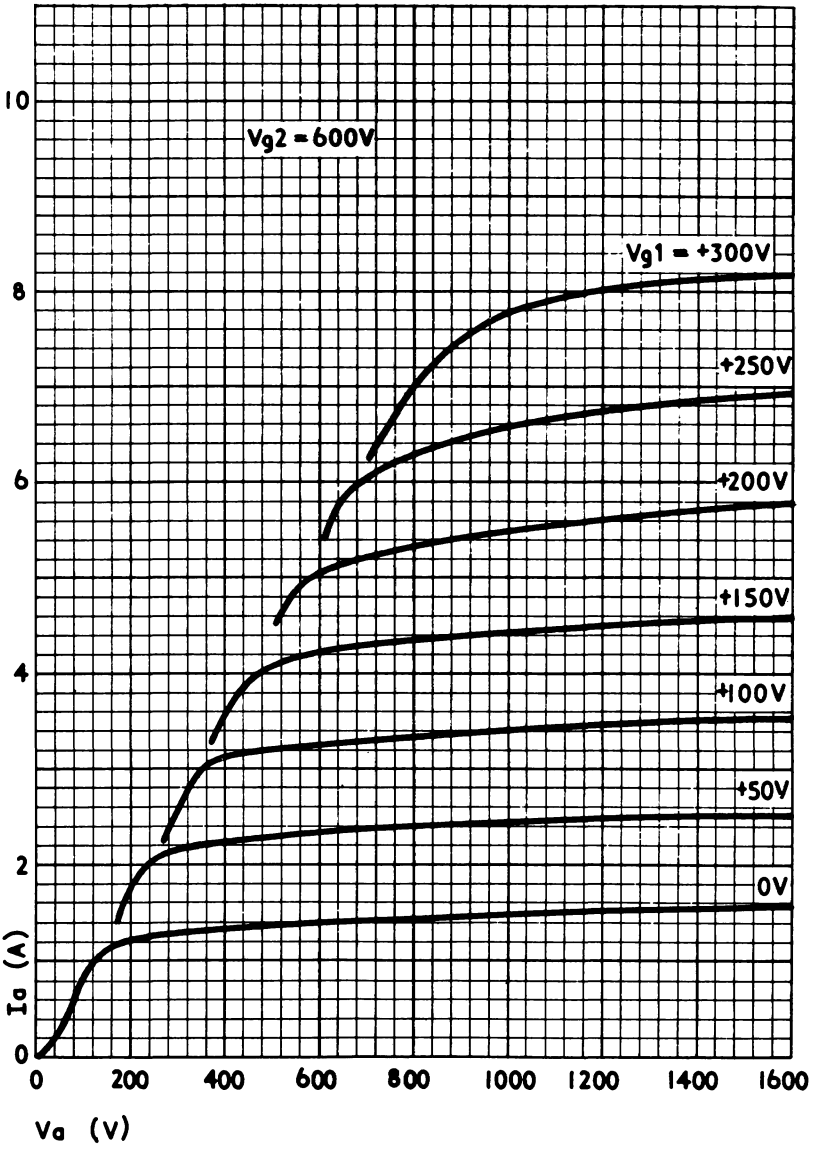

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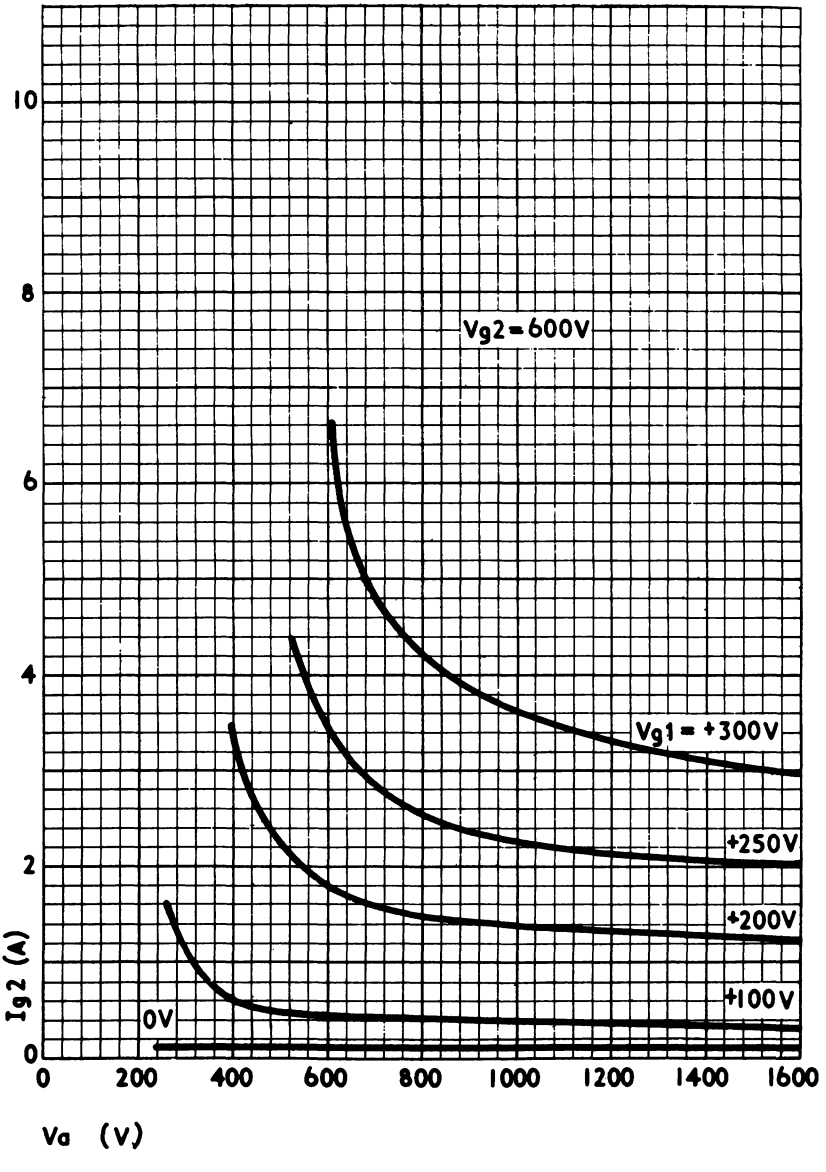

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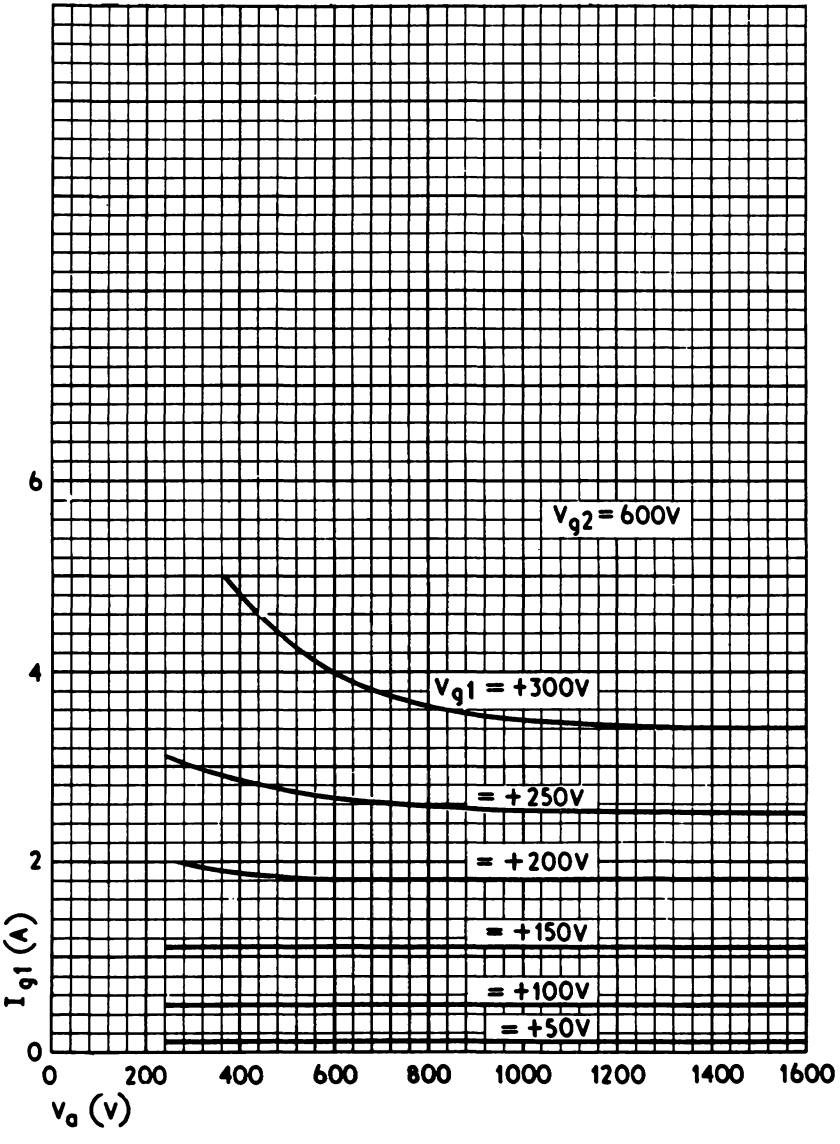
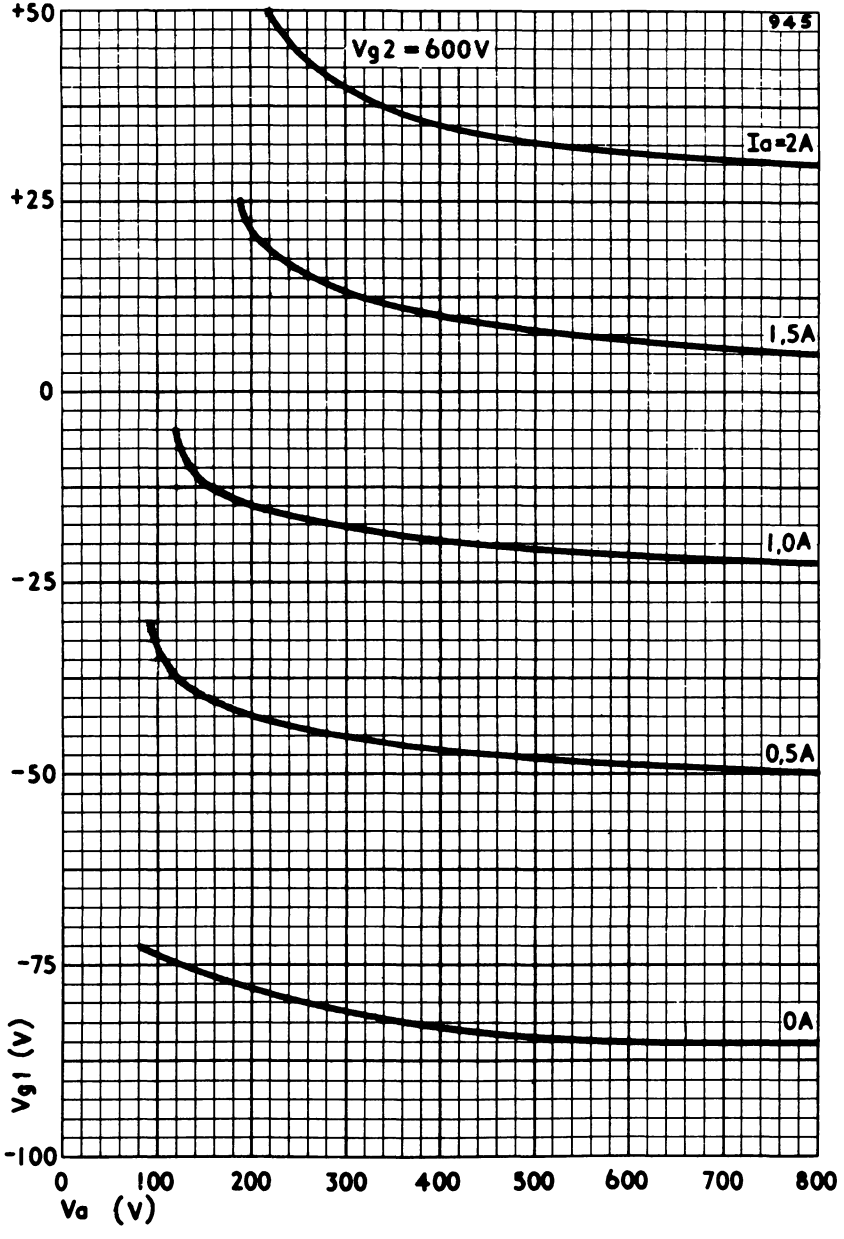


CONSTANT ANODE CURRENT CURVES. SCREEN VOLTAGE AT 600V



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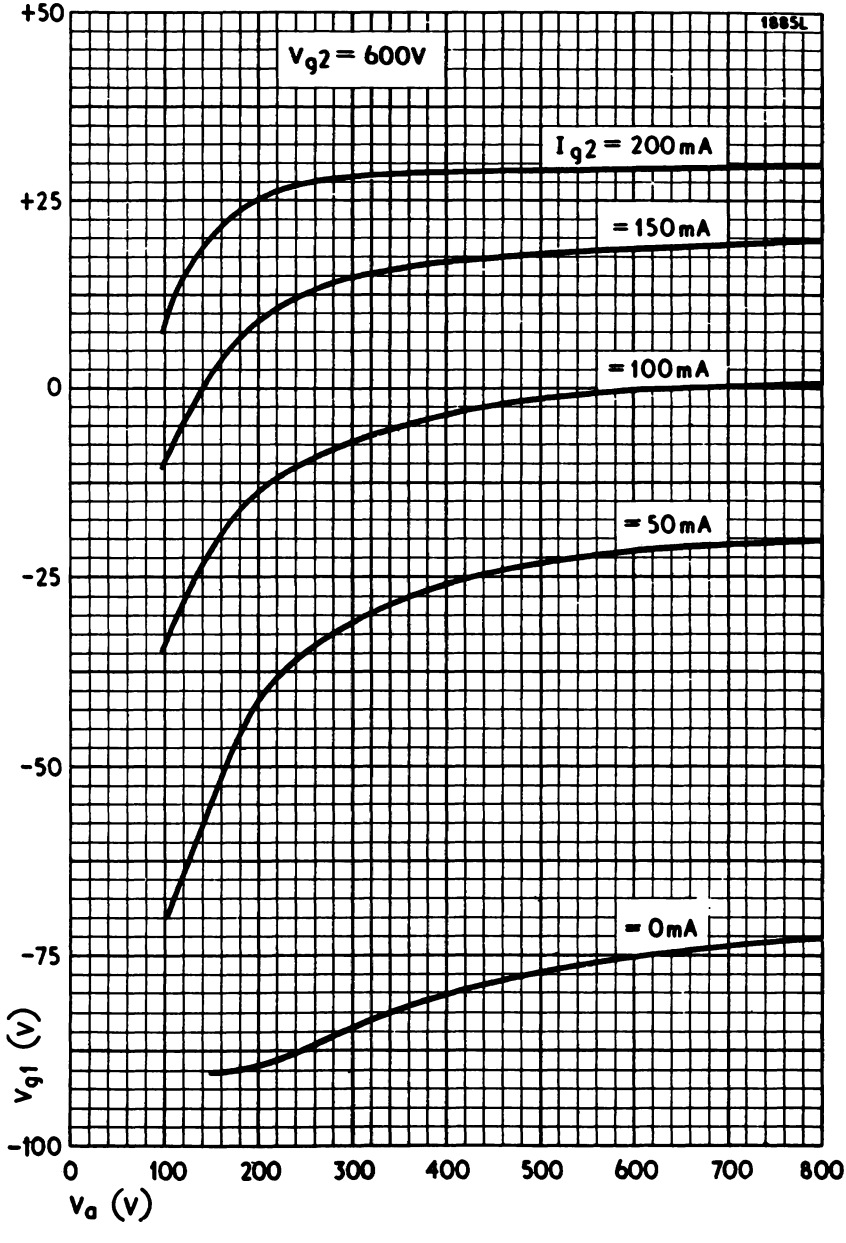
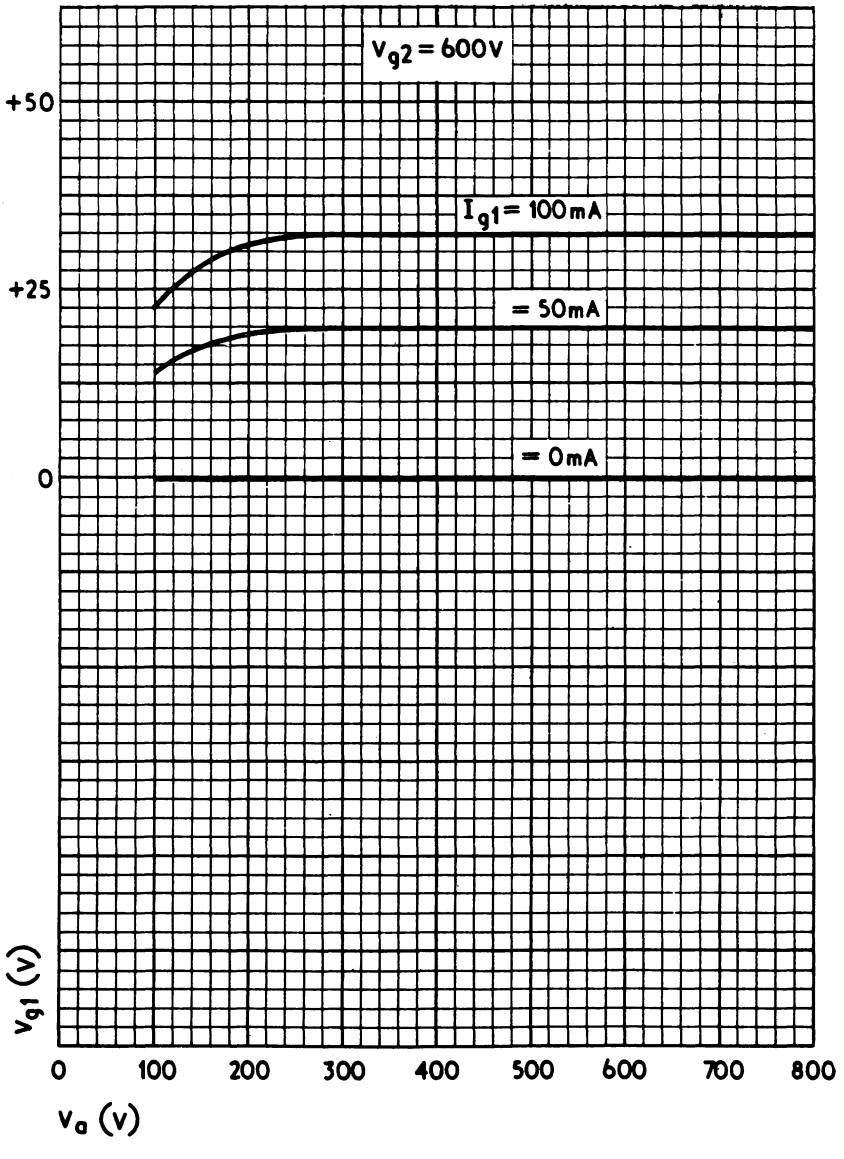
CONSTANT GRID CURRENT CURVES. SCREEN VOLTAGE AT 600V