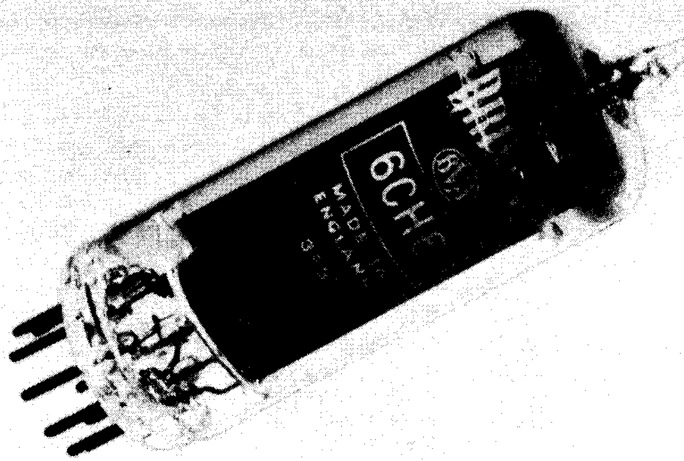


VIDEO PENTODE

APPLICATION REPORT

The 6CH6 is an indirectly heated high slope pentode intended for use as a video amplifier valve. In addition the valve is useful in AF power output stages where high sensitivity is required. Its high slope also makes it eminently suited for use as a triode connected cathode follower amplifier having a low output impedance.

Its heater is intended for use in parallel with those of other valves in AC operated equipment.

NOTE: The maximum ratings given in this report are absolute maxima and should not be exceeded in any circumstances.

DESCRIPTION: The valve is of miniature construction mounted in a T6½ bulb and is fitted with a B9A (Noval) base. Although g_3 is brought out separately to a pin, no purpose is served by connecting it to other than the cathode, as its potential has little effect on the main electron stream. This is because it is not a grid as such but consists of beam confining plates.

Included in this report are characteristic curves and details of the performance of the valve as a video amplifier and AF output stage.

CHARACTERISTICS:

Cathode:	Indirectly heated	
	Voltage	6·3 volts
	Current (Nominal)	0·75 ampere
	Max. DC Heater-Cathode potential	90 volts
Dimensions:	Max. Overall Length	2-5/8 ins.
	Max. Diameter	7/8 in.
	Max. Seated Height	2-3/8 ins.
Base: Type B9A (Noval)	Pin 1 Internal Connection	
	Pin 2 Control Grid	
	Pin 3 Cathode	
	Pin 4 Heater	
	Pin 5 Heater	
	Pin 6 Internal Connection	
	Pin 7 Plate	
	Pin 8 Screen Grid	
	Pin 9 Suppressor Grid	

(Design centre, unless otherwise stated):

PENTODE CONNECTED:

Max. Plate Voltage	275 volts
Max. Screen Voltage	275 volts
Max. Plate Dissipation	12 watts
Max. Screen Dissipation	2·5 watts
Max. DC Cathode Current (Absolute)	65 mA
Max. Peak Cathode Current (Absolute)	1·5 amperes*
Max. Control Grid Circuit Resistance	100,000 ohms†
Max. Bulb Temperature (Absolute)	250° C

TRIODE CONNECTED (Pins 7 and 8 strapped, Pin 9 strapped to Pin 3):

Max. Plate Voltage	275 volts
Max. Plate Dissipation	12·5 watts
Max. DC Cathode Current (Absolute)	65 mA
Max. Peak Cathode Current (Absolute)	1·5 amperes*
Max. Grid Circuit Resistance	100,000 ohms†
Max. Bulb Temperature (Absolute)	250° C

* The duration of current flow must not exceed 2μ seconds, and must not be greater than 5% of the duty cycle.

† This value may be increased to 220,000 ohms if cathode bias is employed.

N.B.—The control grid of this valve is not designed to withstand any appreciable dissipation, therefore no positive DC grid current should be allowed to flow. Precautions must be taken, if the valve is operated at high frequency, to ensure that the AC capacitative current to the control grid is not excessive, otherwise the grid temperature may rise to a level which permits grid emission. This valve is not, therefore, recommended for use as a Class B or C amplifier, or as a frequency multiplier.

Inter-electrode Capacitances (measured with no external shield):

PENTODE CONNECTED:

Input	14 pF
Output	5·0 pF
Grid-Plate	0·25 pF max.
Heater-Cathode	7·0 pF

TRIODE CONNECTED:

Input	8·0 pF
Output	6·0 pF
Grid-Plate	6·0 pF

Characteristic Curves: Curves are contained in this report as follows:

I_p/E_p with E_{g2} 275 volts	No. 307·300
I_p/E_p ,, ,, 250 volts	No. 307·301
I_p/E_p ,, ,, 225 volts	No. 307·302
I_p/E_p ,, ,, 200 volts	No. 307·303
I_p/E_p ,, ,, 175 volts	No. 307·304
I_p/E_p ,, ,, 150 volts	No. 307·305
I_p/E_p ,, ,, 100 volts	No. 307·306
g_m and r_p/E_{g1} with various values of E_{g2}	No. 307·307
I_p/E_p Triode Connected	No. 307·310
μ, g_m and I_p/E_g Triode Connected	No. 307·311

TYPICAL OPERATION:

PENTODE CONNECTED:

Heater Voltage	6·3	6·3	volts
Plate Voltage	250	250	volts
Screen Voltage	200	250	volts
Grid Voltage	—2·5	—4·5	volts
Cathode Bias Resistor	54	100	ohms
Plate Current	40	40	mA
Screen Current	6·5	6·0	mA
Plate Impedance	60,000	50,000	ohms
Mutual Conductance	13	11	mA/V
Inner Amplification Factor	26	26	

TRIODE CONNECTED:

Heater Voltage	6·3	6·3	6·3	volts
Plate Voltage	150	200	250	volts
Grid Voltage	—1·5	—2·5	—4·5	volts
Cathode Bias Resistor	45	57	100	ohms
Plate Current	33	44	46	mA
Plate Impedance	2100	1820	1870	ohms
Mutual Conductance	12·5	14·5	13	mA/V
Amplification Factor	26·2	26·4	25·8	

Operation as an AF Power Output Stage: Where an output valve of high sensitivity is required, such as in circuits containing little or no AF amplification, the 6CH6 is well suited, provided the requirements do not include particularly low harmonic distortion. Due to its high slope, the characteristics have only a limited linear portion over which to accept the grid voltage swing, so that, except at low output levels, the harmonic distortion will be in the order of 7 to 10%. When used in push-pull the even harmonics mostly cancel, and the total distortion level is much lower.

Pentode Connected:

Class 'A' Single Ended:

Plate Voltage	250 volts
Screen Voltage	250 volts
Cathode Bias Resistor	100 ohms
Plate Current	40 mA
Screen Current (no signal)	6·0 mA
Screen Current (max. signal)	8·5 mA
Plate Load Impedance	6000 ohms
Peak Grid Input Voltage	3·5 volts
Power Output	3·0 watts
Total Harmonic Distortion	8·5%

Curves showing the relationship between power output, distortion and input voltage for the above conditions are given in 307·308.

Class 'A' Push-Pull:

Plate Voltage	250 volts
Screen Voltage	250 volts
Plate Current	80 mA
Cathode Bias Resistor	50 ohms
Screen Current (no signal)	12 mA
Screen Current (max. signal)	17·5 mA
Plate to Plate Load Impedance	9000 ohms
Peak Grid to Grid Input Voltage	9·0 volts
Power Output	8·0 watts
Total Harmonic Distortion	7·5%

The above conditions are for two valves.

Curves showing the relationship between power output, distortion and input voltage for the above conditions are given on 307·309.

TRIODE CONNECTED:

Class 'A' Single Ended:

Plate Voltage	250 volts
Cathode Bias Resistor	100 ohms
Plate Current	46 mA
Plate Load Impedance	4000 ohms
Peak Grid Input Voltage	4·5 volts
Power Output	0·8 watt
Total Harmonic Distortion	4%

AN IT&T ASSOCIATE

Class 'A' Push-Pull:

Plate Voltage	250 volts
Cathode Bias Resistor	50 ohms
Plate Current	92 mA
Plate to Plate Load Impedance	5000 ohms
Peak Grid to Grid Input Voltage	9·0 volts
Power Output	1·8 watts
Total Harmonic Distortion	1%

Video Amplifier: Due to its high slope and relatively low output capacity, together with a high standing plate current, the 6CH6 is well suited for wide band amplifier applications where the load resistor must be low to permit working into a high capacity. A low value of plate load resistor is desirable when the overall output capacity is high, as it simplifies the correction for loss of high frequency response.

The normal methods of high frequency compensation are by plate or cathode correction. Examples are given of both methods, and typical performance curves are included.

Plate Compensation: To minimise the effect of capacity in shunt with the output impedance an inductance may be inserted in series with the plate load (shunt compensation), in series with the coupling connection (series compensation), or a combination of the two (series-shunt compensation) may be used. The inductance forms a resonant circuit with the effective output capacity at a frequency above the upper limit of the amplifier response. The rising resonance characteristic is used to counteract the falling load impedance seen by the valve at the upper frequency limit. The load resistor must also be so chosen that the gain at low frequencies, where the reactive effect is small, will be the same as at the upper frequency limit, where the reactive effect predominates. For the purpose of circuit design the upper limit of amplifier response will be considered to be the frequency at which the gain begins to fall below that obtained at mid-band frequencies.

Shunt Compensation: The most widely used method of plate compensation is by shunt peaking, i.e. the peaking inductance is connected in series with the plate load resistor. For design purposes the load resistor is usually made equal to the capacitative impedance at the maximum frequency, and the inductive impedance 1·5 times the capacitative impedance at maximum frequency. This results in the resonant frequency of the combination being $\sqrt{2}$ times the maximum frequency. If the resonant frequency is made too low the amplifier will exhibit a sharp rise in gain followed by a rapid cut-off. If the resonant frequency is made too high the response will fall away slowly, starting at a frequency lower than the desired upper limit. This may be used to advantage when a number of stages are connected in cascade, as any tendency for each stage to exhibit a sharp peak will lead to ringing on transients.

Under these conditions the design formulæ may be simplified to:

$$R_p = \frac{1}{2\pi f \text{ max. } C}$$

$$L = 0{\cdot}5\, C\, R_p{}^2$$

Where R_p is the plate load resistor in ohms, L is the peaking inductance in

AN IT&T ASSOCIATE

henries, C is the total output circuit capacity in farads, and f max. the upper frequency for uniform amplification.

Included in this report are curves showing the peak output voltage as a function of frequency for a typical shunt connected circuit with three values of load resistor and shunt capacity. Curve No. 307·312 shows a load of 1 kΩ, No. 306·313 a load of 2·2 kΩ, and No. 307·314 a load of 3·3 kΩ. Values of C given on the curves include the output capacity of the valve and holder, for which an allowance of 10 pF has been made, but do not include the self capacity of the coil. The values of L, C and R_p differ slightly from those obtained by calculation, this being due to the use of standard preferred value components of normal tolerance, and the fact that the coil self capacity is neglected.

Series Compensation: In this method the peaking inductance is connected in series with the coupling between the stages, thus separating the output capacity of one stage from the input capacity of the other. As the output capacity is usually less than the input capacity the value of R_p may be higher than with shunt compensation for a given upper frequency limit, with a corresponding increase in gain.

If it is assumed that c_{in} is twice the value of c_{out} the design formulæ with the same reservations as before may be simplified to:

$$R_p = \frac{1 \cdot 5}{2\pi \text{ f max. C}}$$

$$L = 0{\cdot}67 \, C \, R_p^2$$

$$\text{Where } C = c_{in} + c_{out}$$

Shunt Series Compensation: This method is a combination of the methods mentioned, and yields a still higher gain than series peaking. With the same reservations as before the design formulæ may be simplified to:

$$R_p = \frac{1 \cdot 8}{2\pi \text{ f max. C}}$$

$$L1 = 0{\cdot}12C \, R_p^2$$

$$L2 = 0{\cdot}52C \, R_p^2$$

Where L1 and L2 are the shunt and series inductances respectively.

Cathode Compensation: The basic principle of this method of compensation is that an inadequately decoupled cathode resistor provides degeneration at low frequencies, the effect of which decreases as the frequency is raised and the impedance of the decoupling condenser falls. By correct proportioning of the bias resistor and by-pass condenser the increase in gain at high frequencies may be used to offset the fall in gain due to the capacitative shunt across the load resistor.

The circuit constants are not so readily calculable as for plate compensation, as a set of characteristics with a number of values of cathode bias resistor is required, and then suitable values have to be selected by trial and error. It has been found preferable to determine the proper values of cathode resistor and by-pass condenser by experiment, bearing in mind that the more compensation required the higher must be the cathode resistor to increase the feed-back factor. The by-pass condenser generally has a value between 200 and 1000 pF.

Two sets of curves are attached showing the performance of the 6CH6 as a cathode compensated amplifier. No. 307·316 shows the performance with a load of 2·2 kΩ shunted by approximately 15 pF and 25 pF, and No. 307·315 shows the performance with a load of 5 kΩ and similar values of capacitative shunt.

In some cases, in order to obtain sufficient feed-back to reach the desired upper frequency limit, the cathode resistor has to be of such a high value that the bias is too high for optimum working. This can be overcome by supplying a small positive bias voltage in opposition obtained from a potential divider from HT to grid and via the grid leak to earth. This is illustrated for condition 2 on Curve No. 307·315.

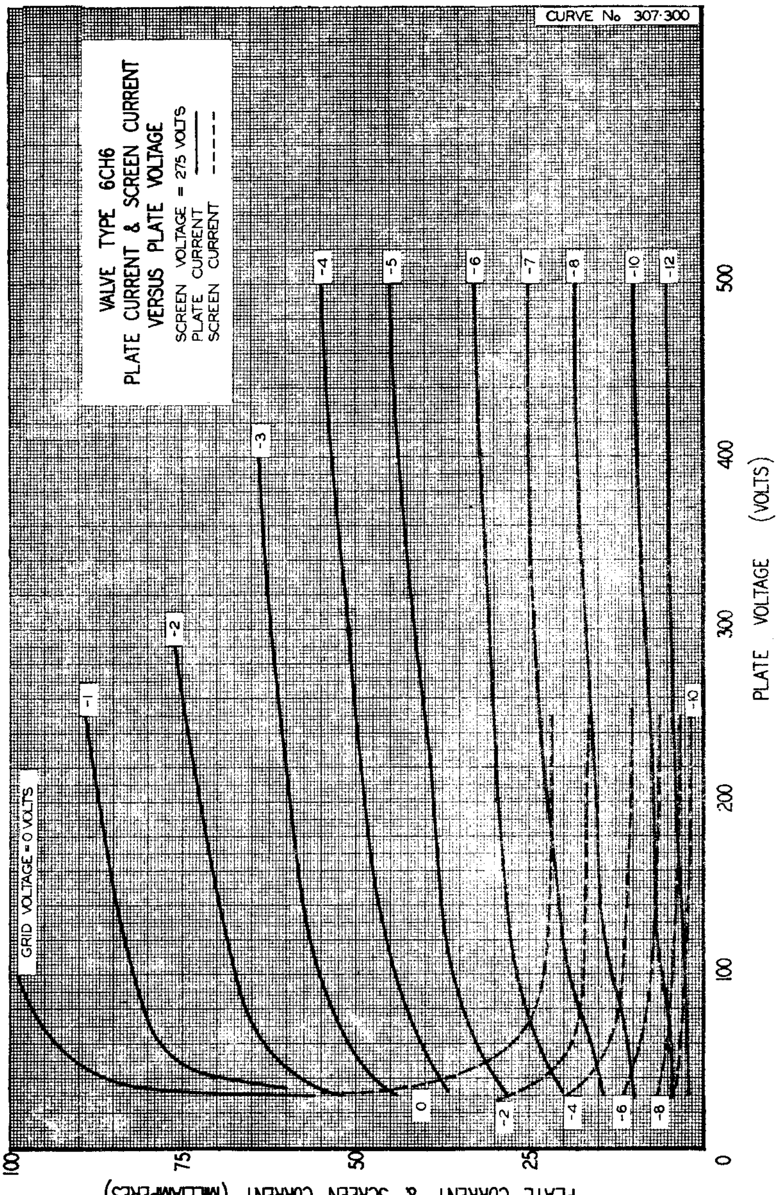
Cathode compensation gives a better low frequency response than plate compensation due to the constant degeneration at low frequencies. The cathode by-pass condenser used with plate compensation, however large, cannot provide effective decoupling at frequencies below 100 c/s.

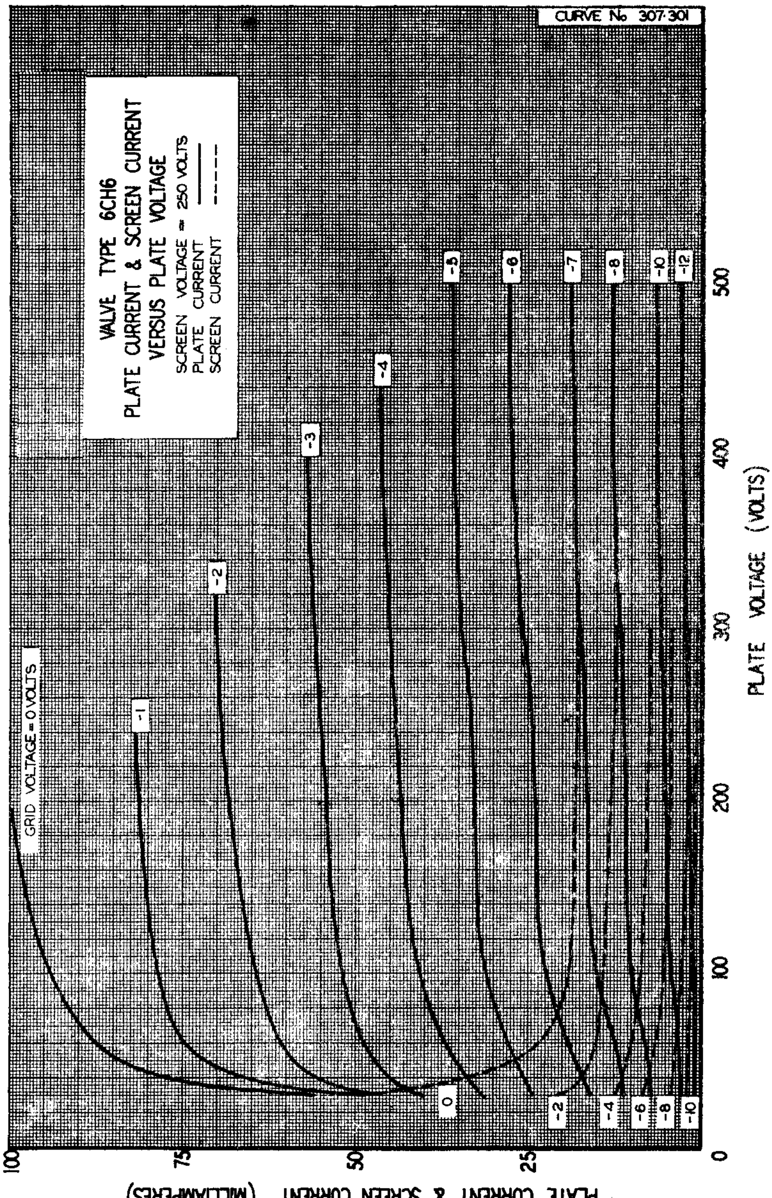
As a result of the degeneration the cathode compensated amplifier suffers from the disadvantage of relatively low gain. The available output voltage is the same as for plate compensation, but a larger input voltage is required to generate it.

Cathode Follower: Due to its high slope the 6CH6 is very suitable for a cathode follower stage where a low output impedance is required. Triode connected, the output impedance varies between 60 and 70 ohms depending on the value of cathode resistor employed. With a 250 volt HT supply the cathode resistor should not be less than 100 ohms as the bias would then be insufficient. When a higher value of cathode resistor is used the grid return should be tapped down it to provide the correct operating bias.

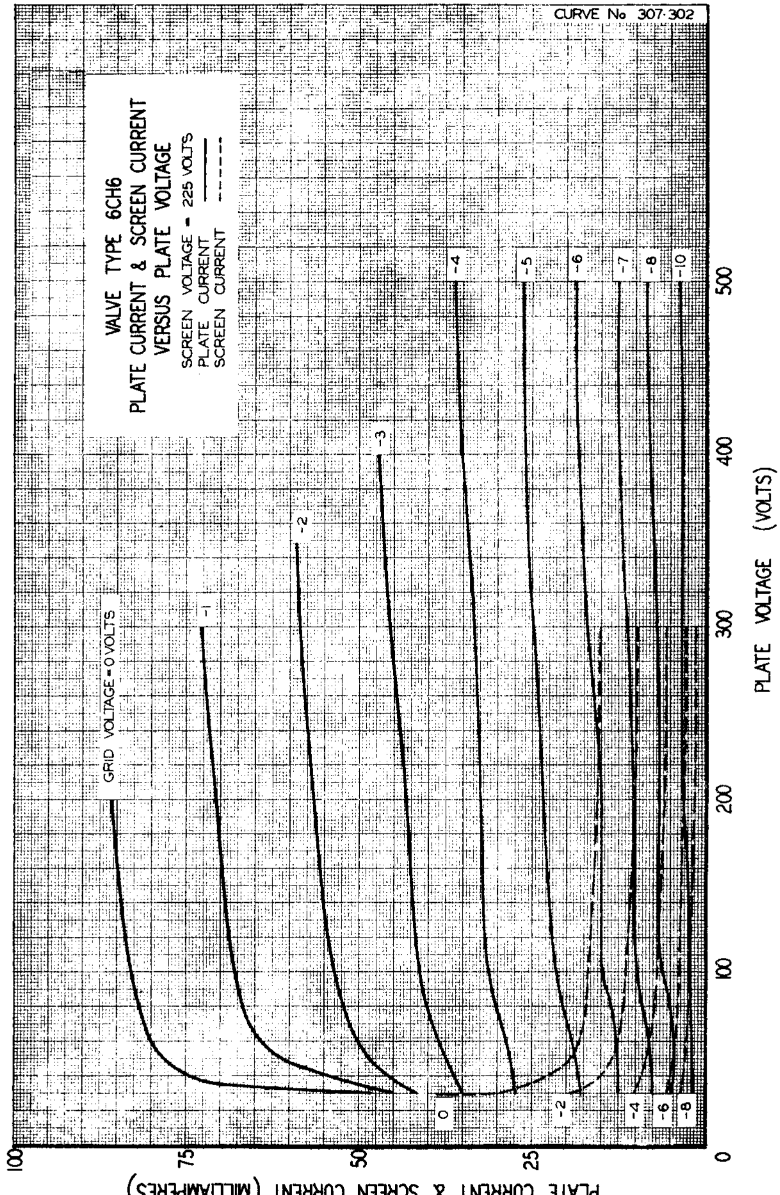
Positive Grid Characteristics: The Curve No. 307·317 shows the characteristics of the 6CH6 with the control grid positive. These curves are useful if the valve is to be used as a pulse modulator or similar application where the control grid is driven positive, as it enables peak plate , screen and grid current to be approximated.

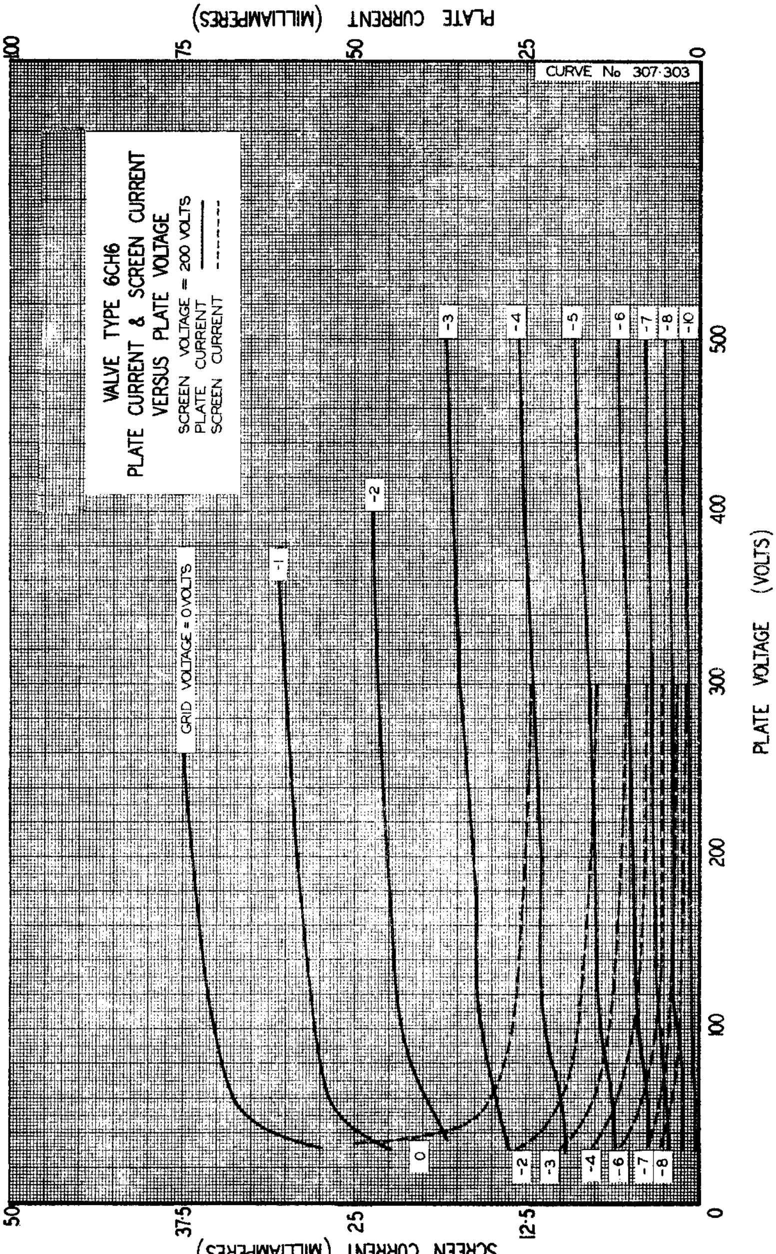
When using the valve with a positively pulsed grid care must be taken not to exceed the ratings given on page 2 and particular attention must be paid to the note on grid dissipation.

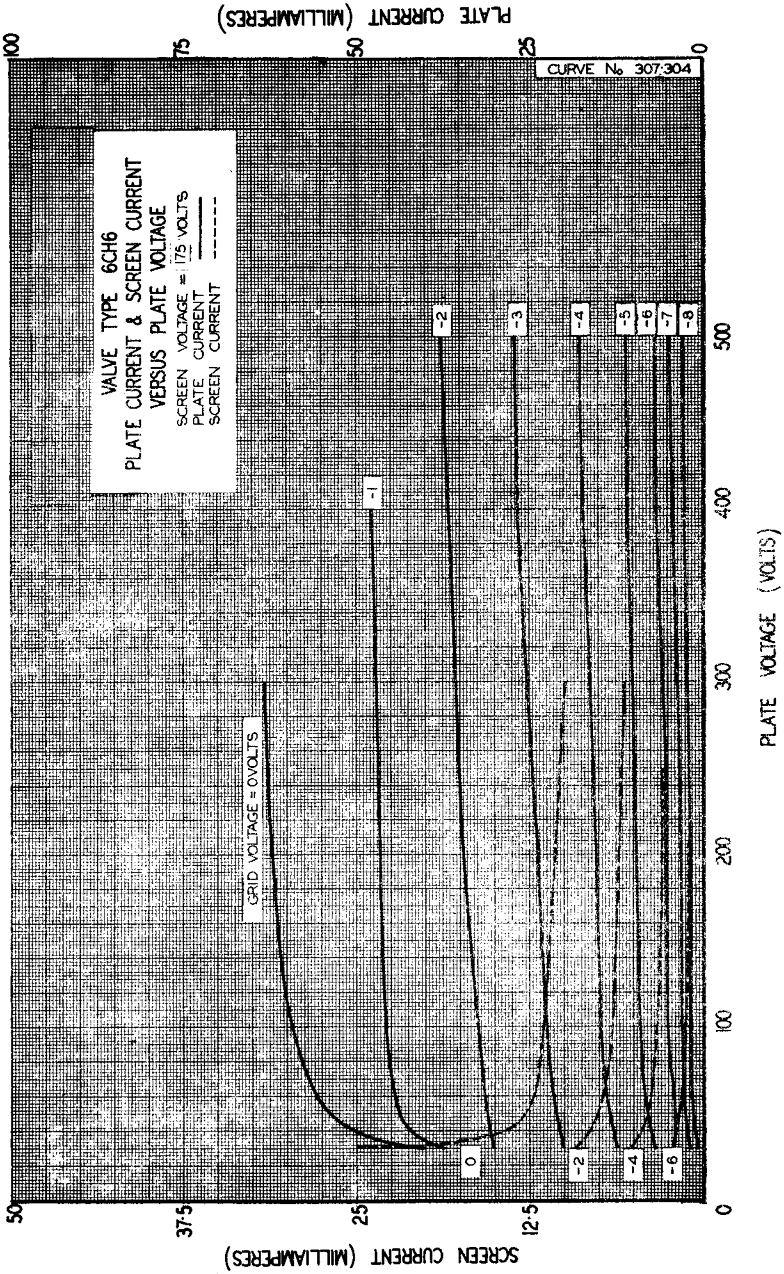

CURVE No 307·300
VALVE TYPE 6CH6
PLATE CURRENT & SCREEN CURRENT
VERSUS PLATE VOLTAGE
SCREEN VOLTAGE = 275 VOLTS
PLATE CURRENT
SCREEN CURRENT
GRID VOLTAGE = 0 VOLTS
-1
-2
-3
-4
-5
-6
-7
-8
-10
-12
0
-2
-4
-6
-8
-10
PLATE VOLTAGE (VOLTS)
0
100
200
300
400
500
PLATE CURRENT & SCREEN CURRENT (MILLIAMPERES)
25
50
75
100

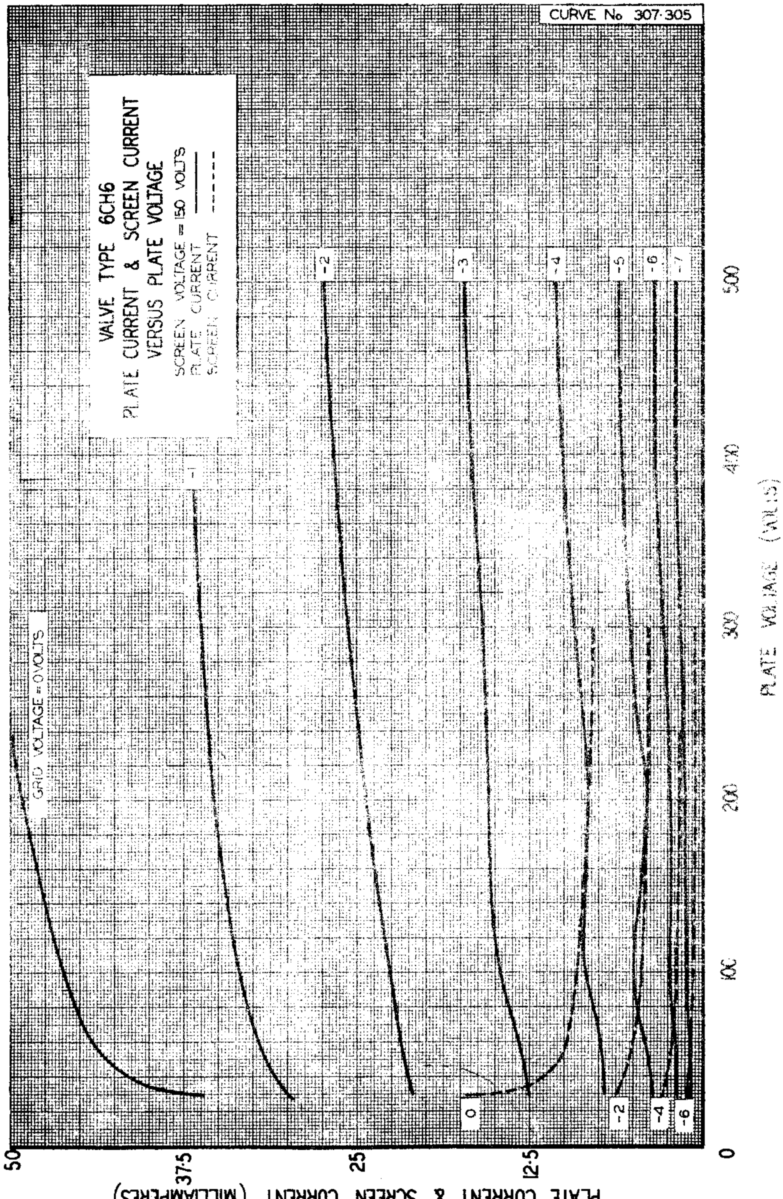


AN IT&T ASSOCIATE

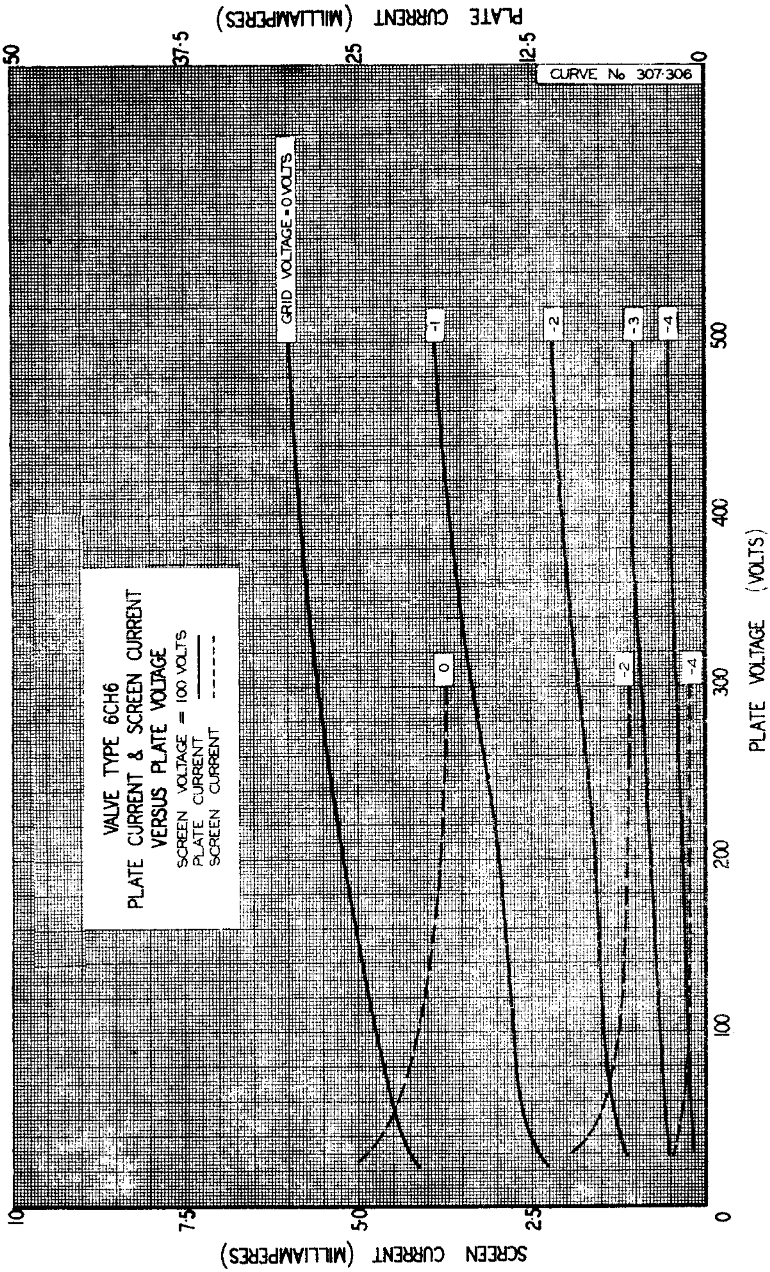

CURVE No 307-302
VALVE TYPE 6CH6
PLATE CURRENT & SCREEN CURRENT
VERSUS PLATE VOLTAGE
SCREEN VOLTAGE - 225 VOLTS
PLATE CURRENT
SCREEN CURRENT
GRID VOLTAGE = 0 VOLTS
-1
-2
-3
-4
-5
-6
-7
-8
-10
0
-2
-4
-6
-8
PLATE VOLTAGE (VOLTS)
0
100
200
300
400
500
PLATE CURRENT & SCREEN CURRENT (MILLIAMPERES)
100
75
50
25

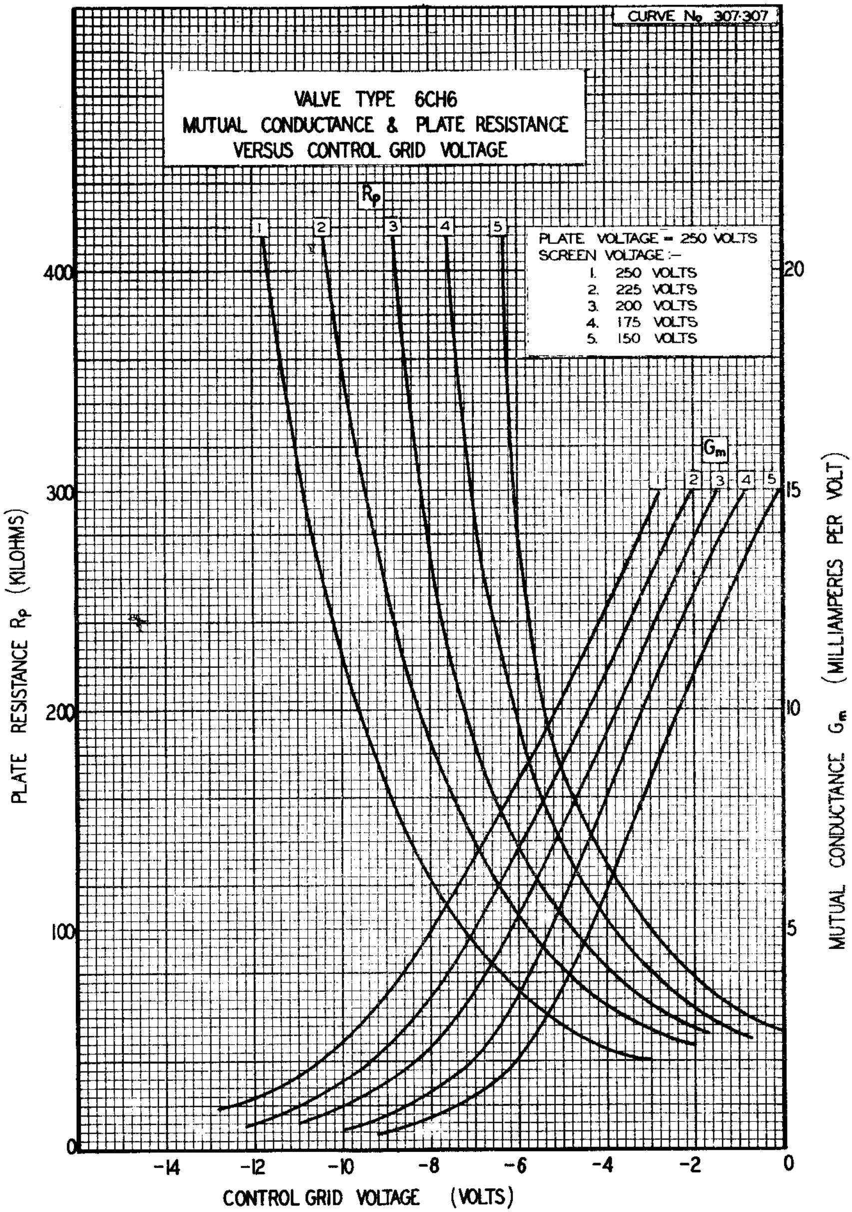

CURVE No 307-303
VALVE TYPE 6CH6
PLATE CURRENT & SCREEN CURRENT
VERSUS PLATE VOLTAGE
SCREEN VOLTAGE = 200 VOLTS
PLATE CURRENT
SCREEN CURRENT
GRID VOLTAGE = 0 VOLTS
PLATE CURRENT (MILLIAMPERES)
SCREEN CURRENT (MILLIAMPERES)
PLATE VOLTAGE (VOLTS)

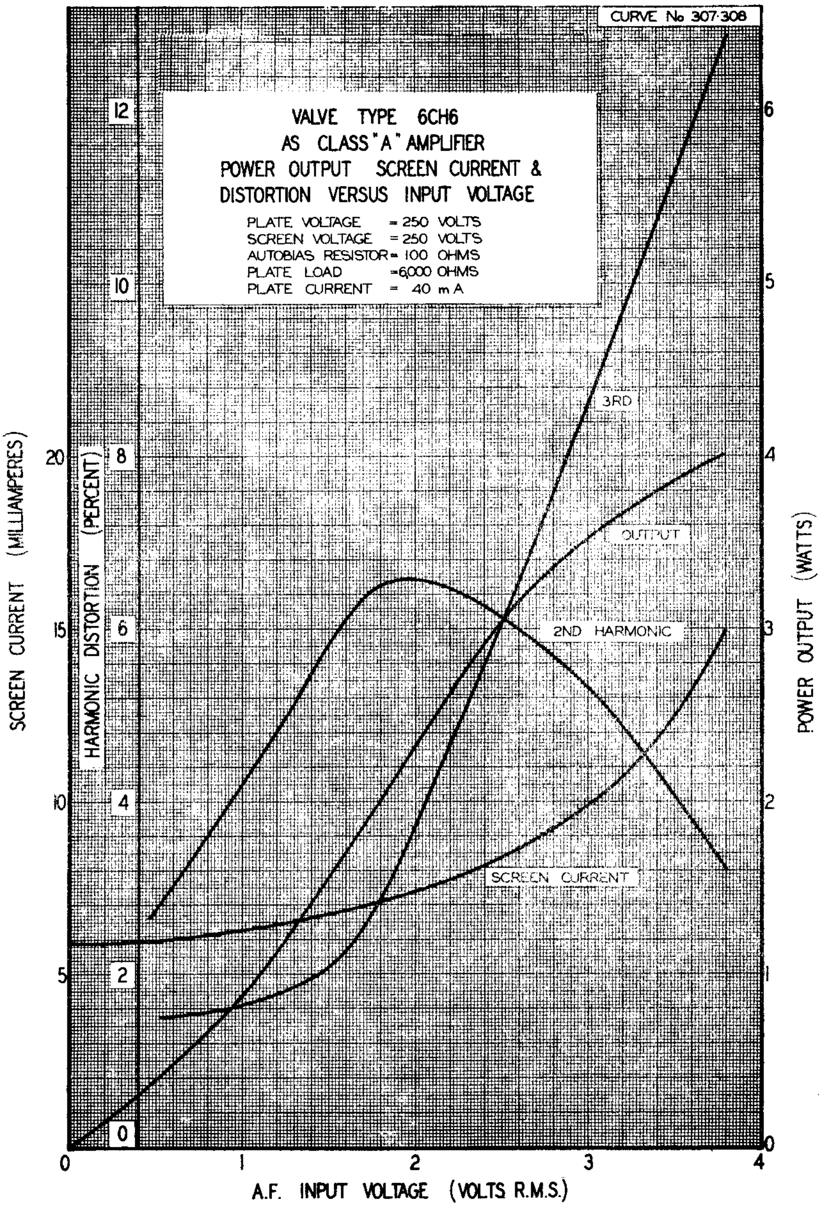

CURVE No 307:304
VALVE TYPE 6CH6
PLATE CURRENT & SCREEN CURRENT
VERSUS PLATE VOLTAGE
SCREEN VOLTAGE = 175 VOLTS
PLATE CURRENT
SCREEN CURRENT
GRID VOLTAGE = 0 VOLTS
-1
-2
-3
-4
-5
-6
-7
-8
0
-2
-4
-6
PLATE CURRENT (MILLIAMPERES)
0
25
50
75
100
PLATE VOLTAGE (VOLTS)
0
100
200
300
400
500
SCREEN CURRENT (MILLIAMPERES)
0
12.5
25
37.5
50

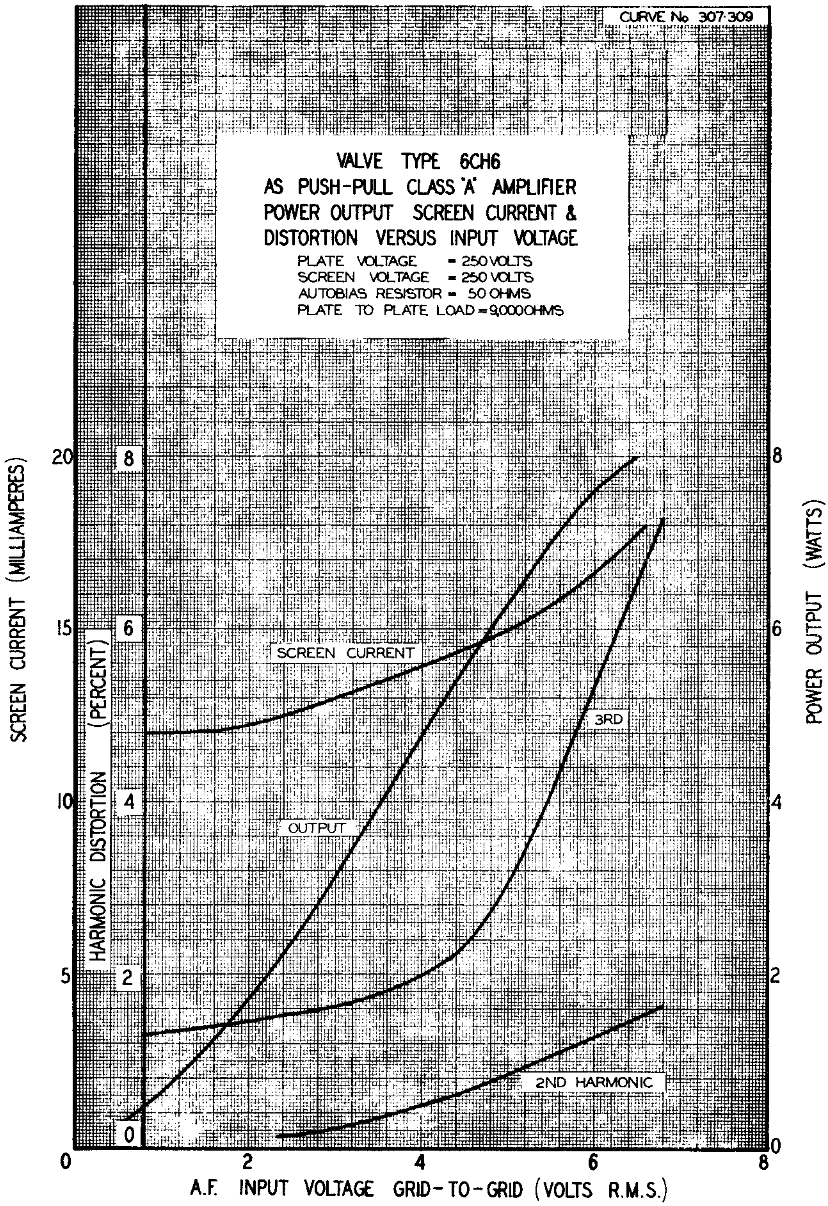


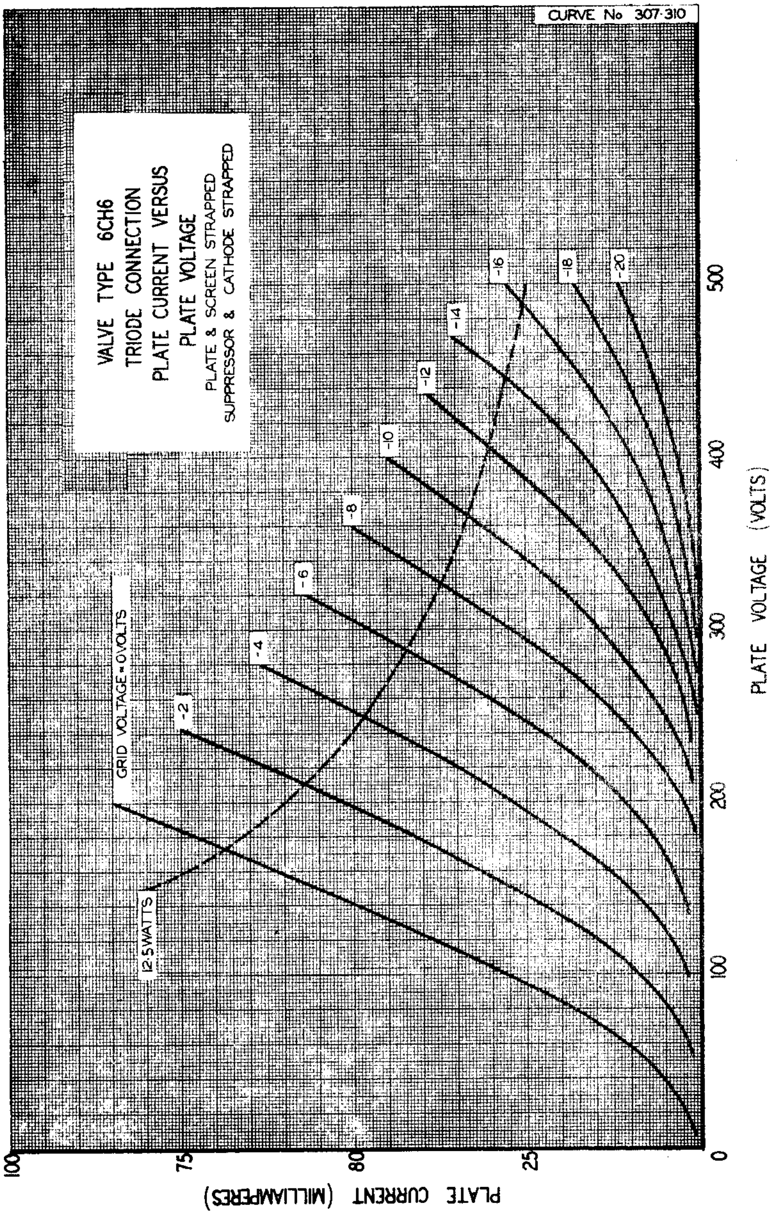
AN IT&T ASSOCIATE

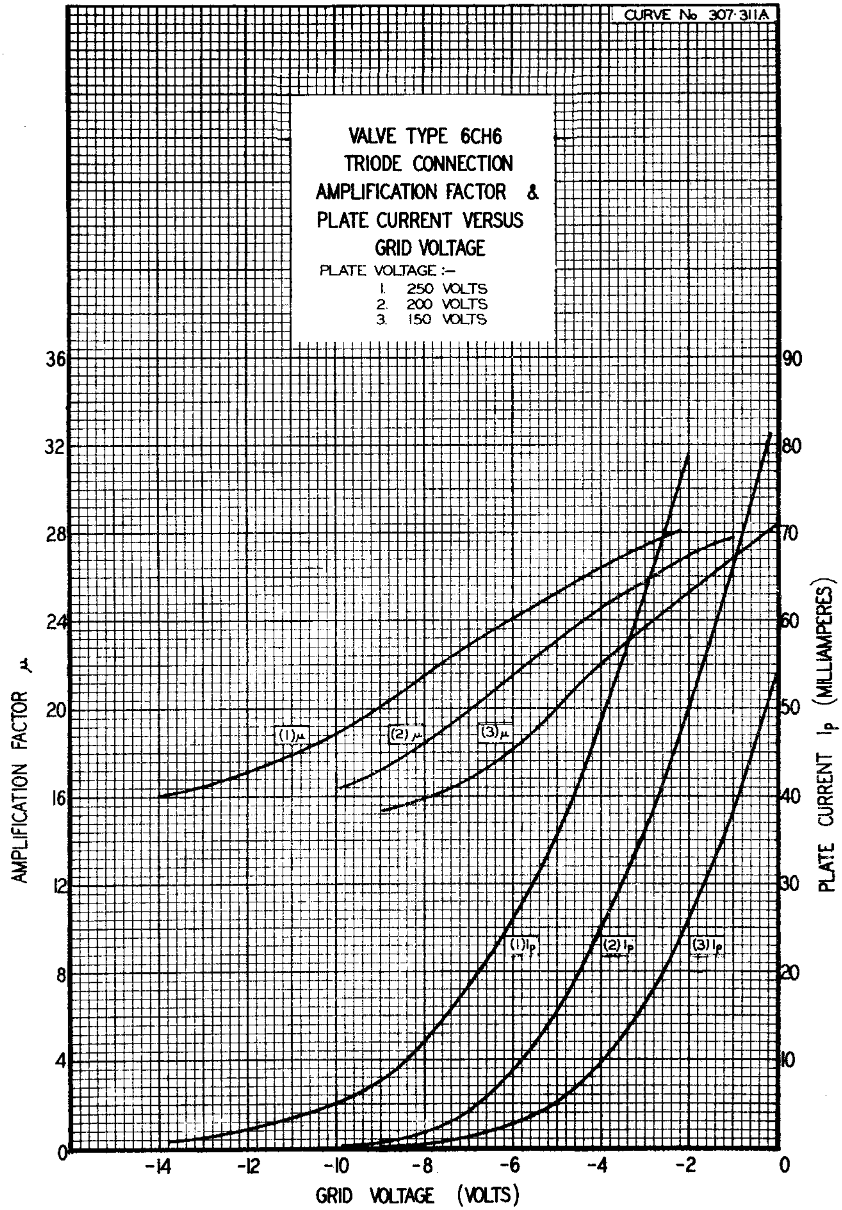

VALVE TYPE 6CH6
PLATE CURRENT & SCREEN CURRENT
VERSUS PLATE VOLTAGE
SCREEN VOLTAGE = 100 VOLTS
PLATE CURRENT
SCREEN CURRENT
CURVE No 307·306
GRID VOLTAGE = 0 VOLTS
-1
-2
-3
-4
0
-2
-4
PLATE CURRENT (MILLIAMPERES)
0
12·5
25
37·5
50
SCREEN CURRENT (MILLIAMPERES)
0
2·5
5·0
7·5
10
PLATE VOLTAGE (VOLTS)
100
200
300
400
500

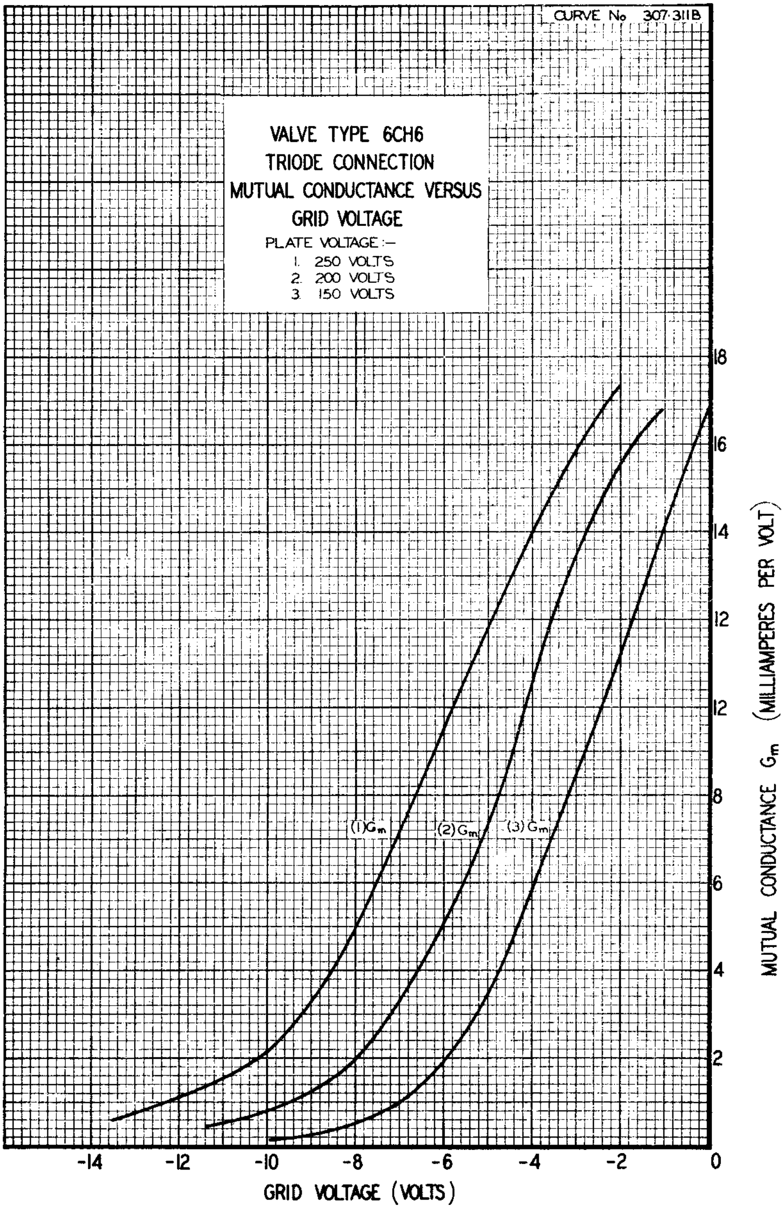

CURVE No 307-307
VALVE TYPE 6CH6
MUTUAL CONDUCTANCE & PLATE RESISTANCE
VERSUS CONTROL GRID VOLTAGE
Rp
1 2 3 4 5
PLATE VOLTAGE = 250 VOLTS
SCREEN VOLTAGE :-
1. 250 VOLTS
2. 225 VOLTS
3. 200 VOLTS
4. 175 VOLTS
5. 150 VOLTS
Gm
1 2 3 4 5
400
300
200
100
0
20
15
10
5
0
-14 -12 -10 -8 -6 -4 -2 0
PLATE RESISTANCE Rp (KILOHMS)
MUTUAL CONDUCTANCE Gm (MILLIAMPERES PER VOLT)
CONTROL GRID VOLTAGE (VOLTS)

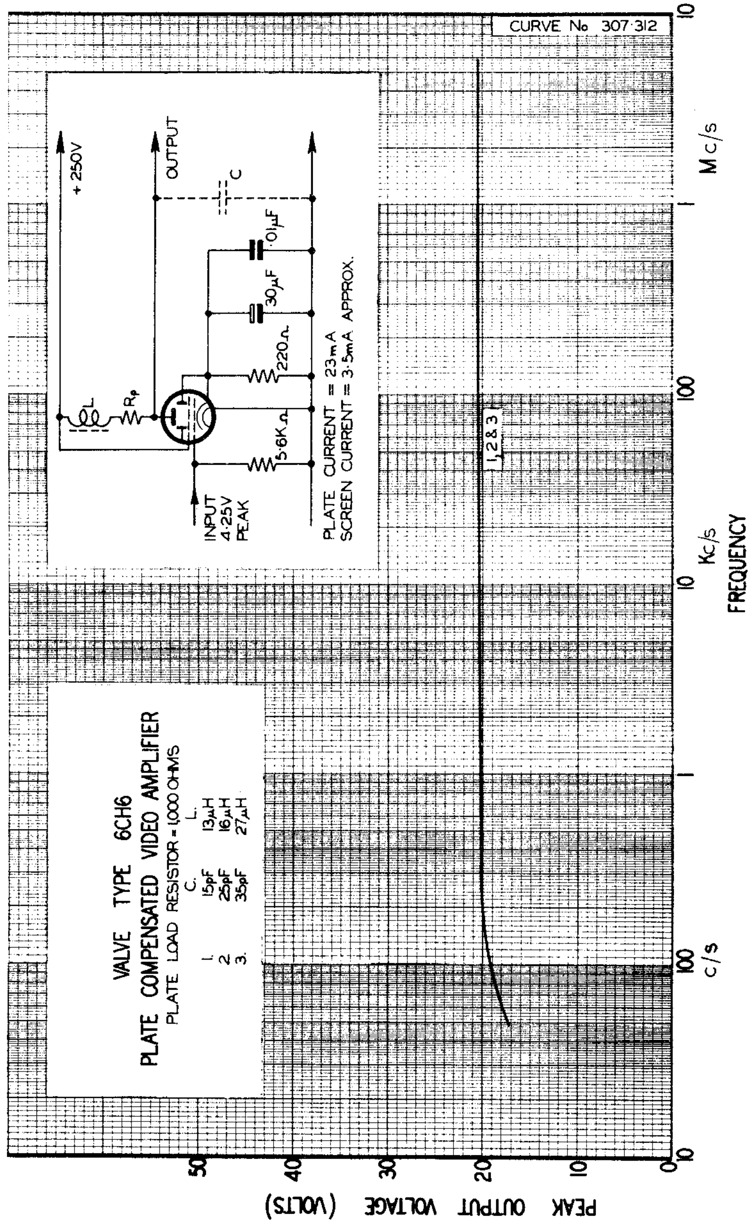

CURVE No 307-308
VALVE TYPE 6CH6
AS CLASS "A" AMPLIFIER
POWER OUTPUT SCREEN CURRENT &
DISTORTION VERSUS INPUT VOLTAGE
PLATE VOLTAGE = 250 VOLTS
SCREEN VOLTAGE = 250 VOLTS
AUTOBIAS RESISTOR = 100 OHMS
PLATE LOAD = 6,000 OHMS
PLATE CURRENT = 40 mA
3RD
OUTPUT
2ND HARMONIC
SCREEN CURRENT
SCREEN CURRENT (MILLIAMPERES)
HARMONIC DISTORTION (PERCENT)
POWER OUTPUT (WATTS)
A.F. INPUT VOLTAGE (VOLTS R.M.S.)
0
1
2
3
4
5
10
15
20
12
10
8
6
4
2
0
6
5
4
3
2
1
0

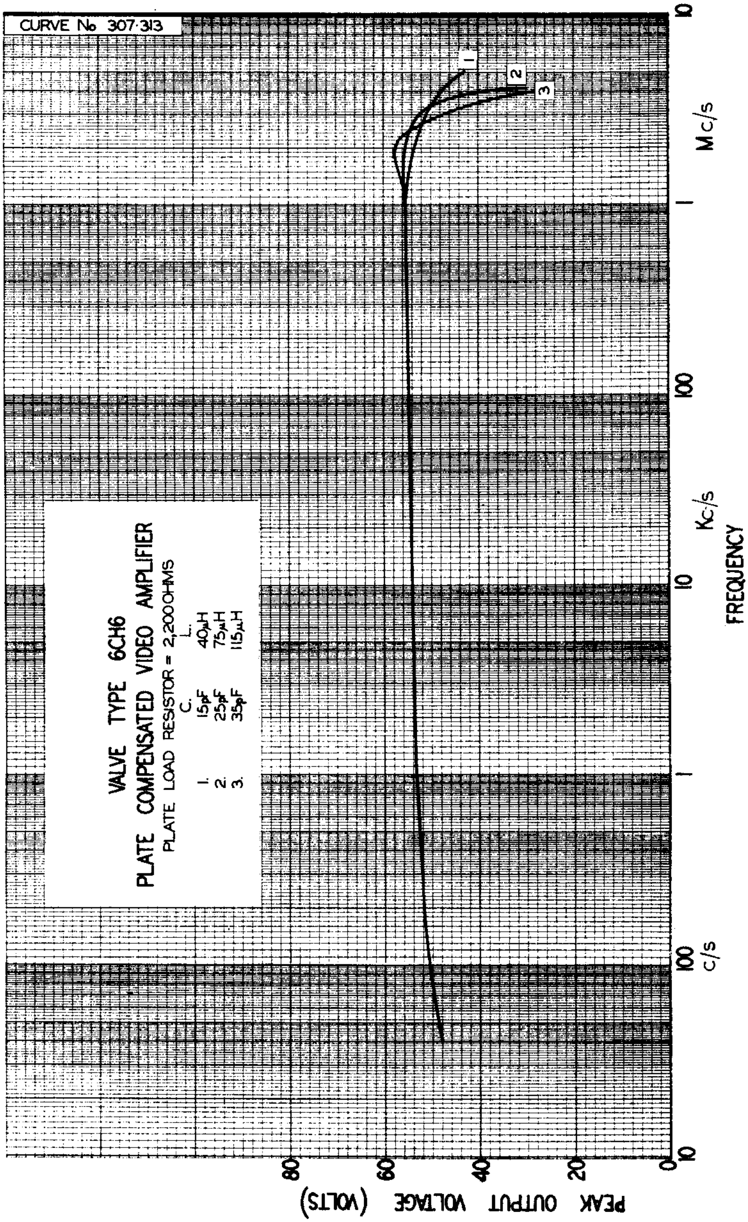

CURVE No 307-309
VALVE TYPE 6CH6
AS PUSH-PULL CLASS 'A' AMPLIFIER
POWER OUTPUT SCREEN CURRENT &
DISTORTION VERSUS INPUT VOLTAGE
PLATE VOLTAGE = 250 VOLTS
SCREEN VOLTAGE = 250 VOLTS
AUTOBIAS RESISTOR = 50 OHMS
PLATE TO PLATE LOAD = 9,000 OHMS
SCREEN CURRENT
OUTPUT
3RD
2ND HARMONIC
SCREEN CURRENT (MILLIAMPERES)
HARMONIC DISTORTION (PERCENT)
POWER OUTPUT (WATTS)
A.F. INPUT VOLTAGE GRID-TO-GRID (VOLTS R.M.S.)
0
5
10
15
20
2
4
6
8

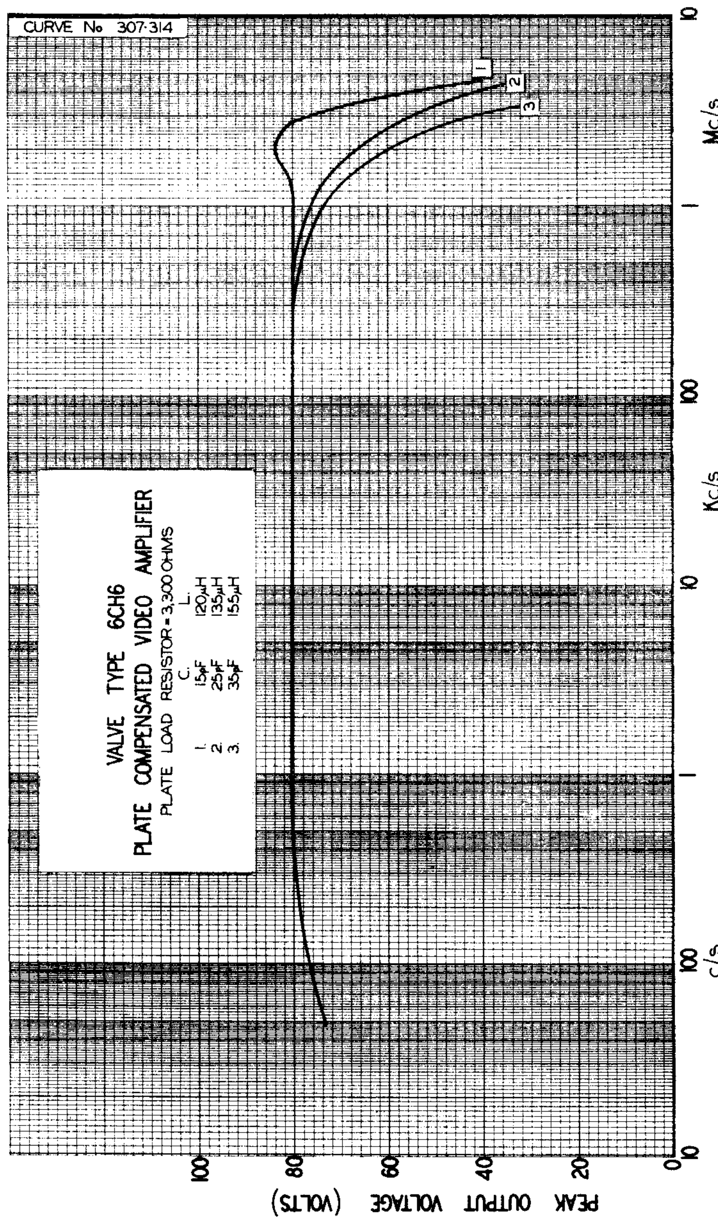

CURVE No 307·310
VALVE TYPE 6CH6
TRIODE CONNECTION
PLATE CURRENT VERSUS
PLATE VOLTAGE
PLATE & SCREEN STRAPPED
SUPPRESSOR & CATHODE STRAPPED
GRID VOLTAGE = 0 VOLTS
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
12·5 WATTS
PLATE CURRENT (MILLIAMPERES)
PLATE VOLTAGE (VOLTS)
0
100
200
300
400
500
25
50
75
100


CURVE No 307·311A
VALVE TYPE 6CH6
TRIODE CONNECTION
AMPLIFICATION FACTOR &
PLATE CURRENT VERSUS
GRID VOLTAGE
PLATE VOLTAGE :–
1. 250 VOLTS
2. 200 VOLTS
3. 150 VOLTS
(1)μ
(2)μ
(3)μ
(1)Ip
(2)Ip
(3)Ip
AMPLIFICATION FACTOR μ
PLATE CURRENT Ip (MILLIAMPERES)
GRID VOLTAGE (VOLTS)
0
4
8
12
16
20
24
28
32
36
10
20
30
40
50
60
70
80
90
-14
-12
-10
-8
-6
-4
-2
0

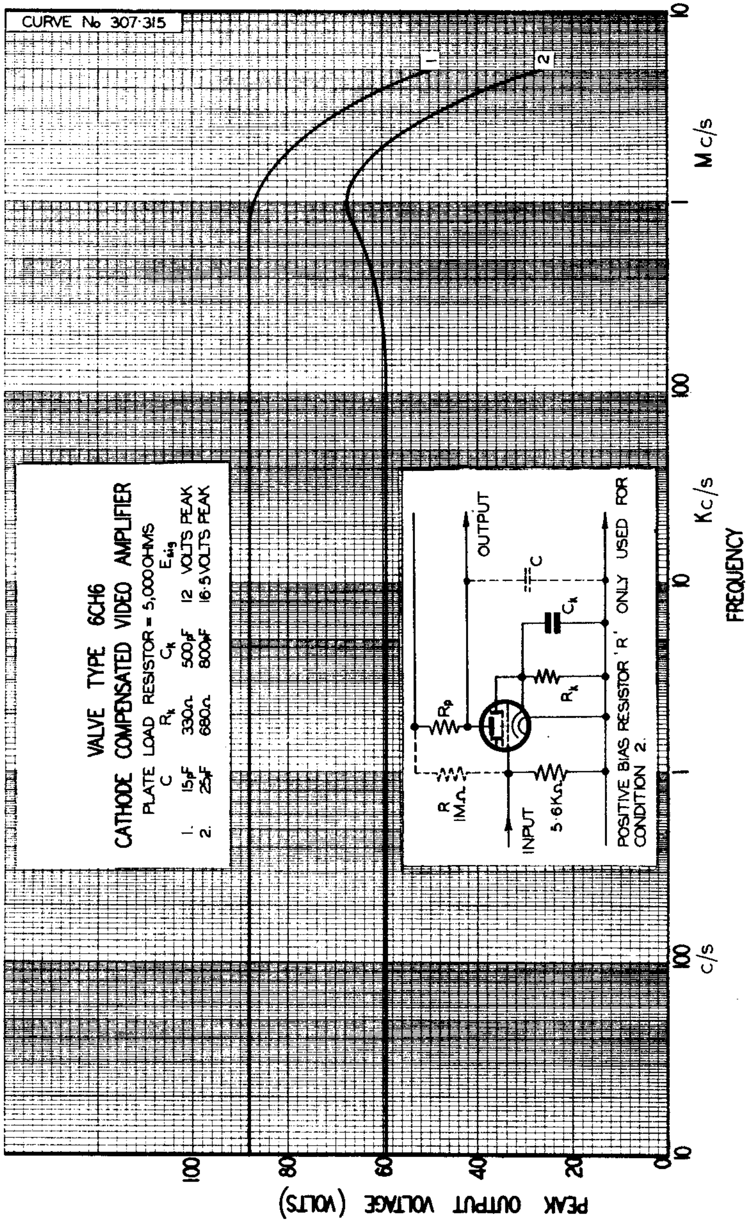

CURVE No 307·311B
VALVE TYPE 6CH6
TRIODE CONNECTION
MUTUAL CONDUCTANCE VERSUS
GRID VOLTAGE
PLATE VOLTAGE :—
1. 250 VOLTS
2. 200 VOLTS
3. 150 VOLTS
(1) G_m
(2) G_m
(3) G_m
18
16
14
12
12
8
6
4
2
0
-14
-12
-10
-8
-6
-4
-2
GRID VOLTAGE (VOLTS)
MUTUAL CONDUCTANCE G_m (MILLIAMPERES PER VOLT)

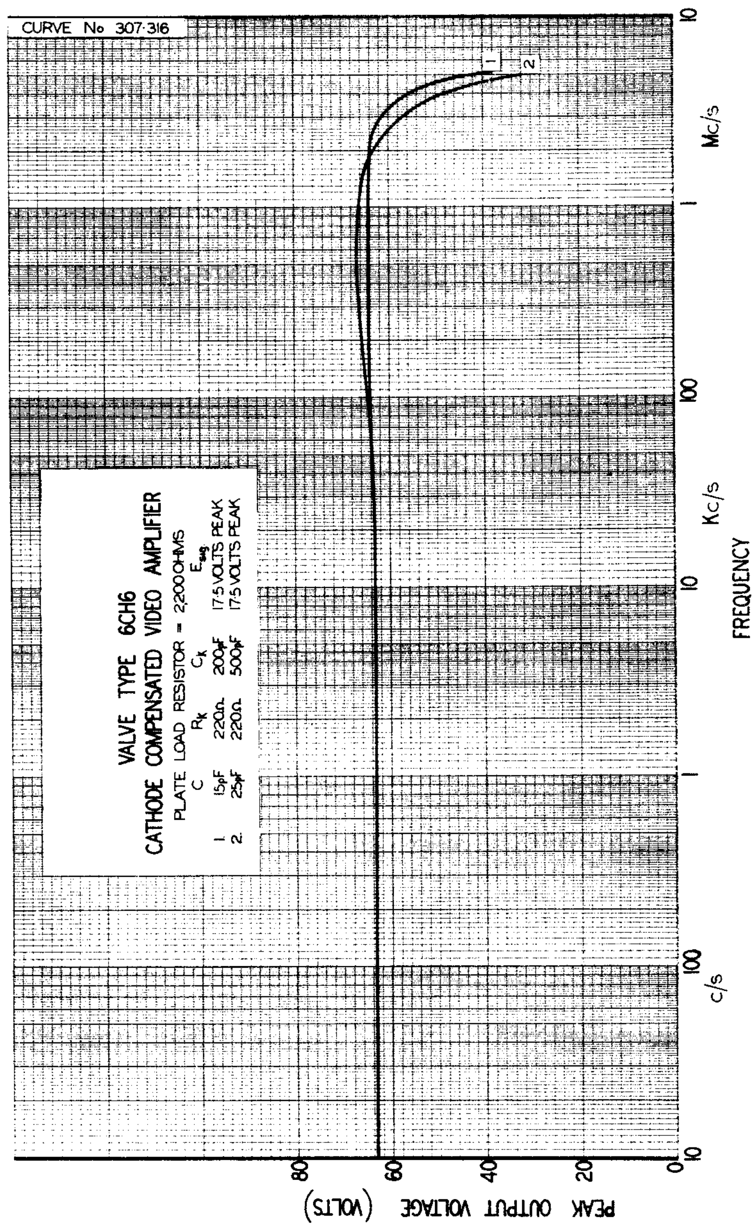

CURVE No 307·312
VALVE TYPE 6CH6
PLATE COMPENSATED VIDEO AMPLIFIER
PLATE LOAD RESISTOR = 1,000 OHMS
C. L.
1. 15pF 13μH
2. 25pF 16μH
3. 35pF 27μH
+ 250V
OUTPUT
C
·01μF
30μF
220Ω
5·6KΩ
L
R_p
INPUT
4·25V
PEAK
PLATE CURRENT = 23mA
SCREEN CURRENT = 3·5mA APPROX.
1,2&3
10
100
c/s
1
10
Kc/s
100
1
Mc/s
10
FREQUENCY
PEAK OUTPUT VOLTAGE (VOLTS)
0
10
20
30
40
50


CURVE No 307·313
VALVE TYPE 6CH6
PLATE COMPENSATED VIDEO AMPLIFIER
PLATE LOAD RESISTOR = 2,200 OHMS
C. L.
1. 15pF 40µH
2. 25pF 75µH
3. 35pF 115µH
1
2
3
10
100
c/s
1
10
Kc/s
100
1
Mc/s
10
FREQUENCY
0
20
40
60
80
PEAK OUTPUT VOLTAGE (VOLTS)



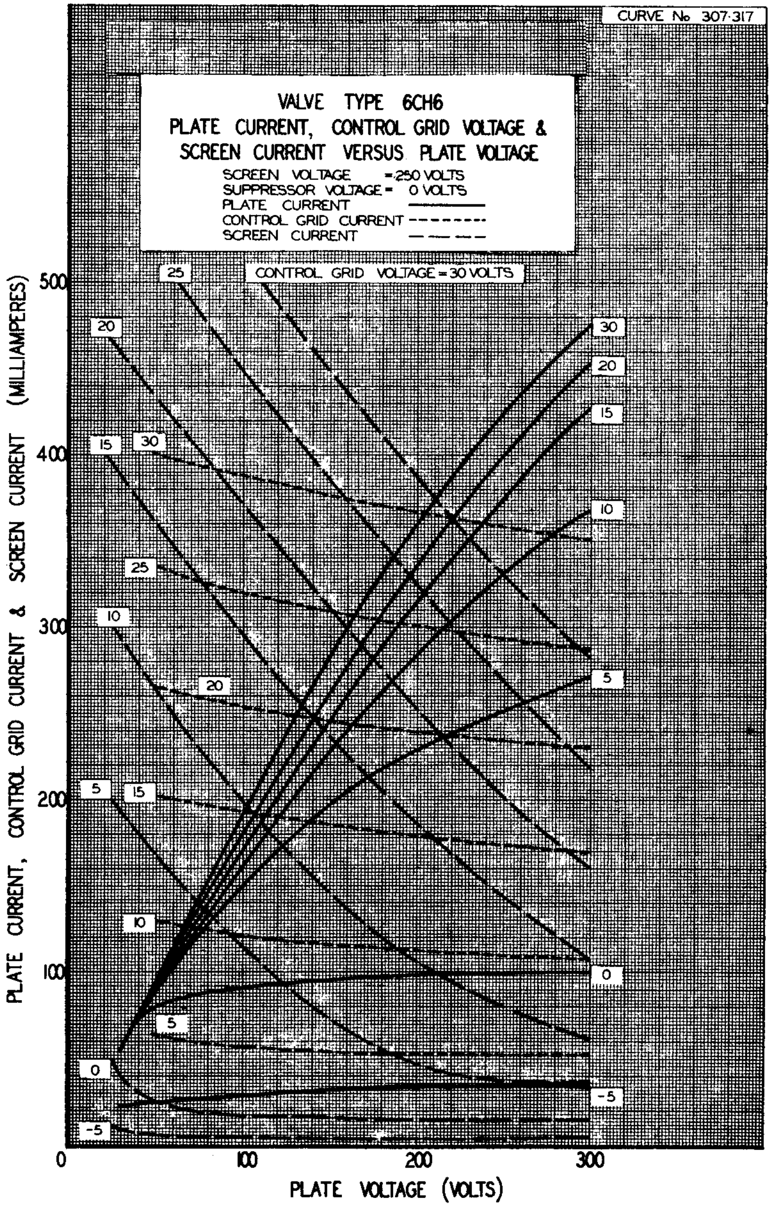
AN IT&T ASSOCIATE


CURVE No 307·315
VALVE TYPE 6CH6
CATHODE COMPENSATED VIDEO AMPLIFIER
PLATE LOAD RESISTOR = 5,000 OHMS
C Rk Ck Esig
1. 15pF 330Ω 500μF 12 VOLTS PEAK
2. 25pF 680Ω 800μF 16·5 VOLTS PEAK
OUTPUT
INPUT
R 1MΩ
5·6KΩ
Rp
Rk
Ck
C
POSITIVE BIAS RESISTOR 'R' ONLY USED FOR CONDITION 2.
1
2
PEAK OUTPUT VOLTAGE (VOLTS)
0
20
40
60
80
100
FREQUENCY
10
100
c/s
1
10
100
Kc/s
1
10
Mc/s



CURVE No 307·316
VALVE TYPE 6CH6
CATHODE COMPENSATED VIDEO AMPLIFIER
PLATE LOAD RESISTOR = 2,200 OHMS
C R_K C_K E_sig
1 15pF 220Ω 200µF 17·5 VOLTS PEAK
2 25pF 220Ω 500µF 17·5 VOLTS PEAK
PEAK OUTPUT VOLTAGE (VOLTS)
0 20 40 60 80
FREQUENCY
10 100 c/s
1 10 100 Kc/s
1 10 Mc/s
1
2

AN IT&T ASSOCIATE


CURVE No 307·317
VALVE TYPE 6CH6
PLATE CURRENT, CONTROL GRID VOLTAGE & SCREEN CURRENT VERSUS PLATE VOLTAGE
SCREEN VOLTAGE = 250 VOLTS
SUPPRESSOR VOLTAGE = 0 VOLTS
PLATE CURRENT
CONTROL GRID CURRENT
SCREEN CURRENT
CONTROL GRID VOLTAGE = 30 VOLTS
25
20
15
10
5
0
-5
30
25
20
15
10
5
30
20
15
10
5
0
-5
PLATE CURRENT, CONTROL GRID CURRENT & SCREEN CURRENT (MILLIAMPERES)
500
400
300
200
100
0
100
200
300
PLATE VOLTAGE (VOLTS)