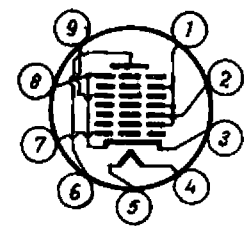
Type 6BE7

Enneode for F.M. detection, amplitude limitation and A.F. amplification

Physical specifications

Cathode	Coated unipotential
Base	Small button noval 9-pin
Bulb	T 6½
Maximum overall length	2-5/8 inches
Maximum seated height	2-3/8 inches
Bulb length excluding tip	2±3/32 inches
Maximum diameter	7/8 inches
Mounting position	any
Basing connections - JETEC basing designation	9AA-0-0

Pin 1 - Grids No. 2,4 and 6
Pin 2 - Grid No. 3
Pin 3 - Cathode and grid No. 7
Pin 4 - Heater
Pin 5 - Heater
Pin 6 - Plate
Pin 7 - Grid No. 1
Pin 8 - Cathode and grid No. 7
Pin 9 - Grid No. 5



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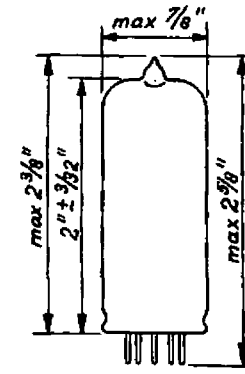

General Electrical Data

Heater voltage	6.3 volts
Heater current	0.2 ampere

Direct interelectrode capacitances

Plate to all other elements	8.7 μμF
Grid No. 3 to all other elements	5.8 μμF
Grid No. 5 to all other elements	8.2 μμF
Grid No. 1 to all other elements	4.2 μμF
Plate to grid No. 1	max. 0.40 μμF
Plate to grid No. 3	max. 0.15 μμF
Plate to grid No. 5	max. 0.35 μμF
Grid No. 3 to grid No. 5	max. 0.40 μμF
Grid No. 1 to heater	max. 0.20 μμF
Grid No. 3 to heater	max. 0.15 μμF
Grid No. 5 to heater	max. 0.15 μμF

Maximum Ratings

Plate voltage (without current)	550	volts
Plate voltage	250	volts
Plate dissipation	0.1	watt
Grid No. 2, 4 and 6 voltage (without current)	250	volts
Grid No. 2, 4 and 6 voltage	100	volts
Grid No. 2, 4 and 6 dissipation	0.1	watt
Cathode current	3	ma

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from RMA release #837, March 15, 1950

Maximum Ratings (continued)

Grid No. 1 voltage at grid No. 1 current = +0.3 µa	-1.3	volts	
Grid No. 3 voltage at grid No. 3 current = +0.3 µa	-1.3	volts	
Grid No. 5 voltage at grid No. 5 current = +0.3 µa	-1.3	volts	
External resistance between grid No. 1 and cathode	1	megohm	1)
External resistance between heater and cathode	20,000	ohms	
Voltage between heater and cathode	100	volts	

Operating conditions as F.M. detector (see fig. 1)

Plate supply voltage	250	volts
Plate load resistance	0.47	megohm
Resistance R1	34,000	ohms
Resistance R2	3,900	ohms
Resistance R3	560	ohms
Grid No.3 input voltage (RMS value)	12	volts
Grid No.5 input voltage (RMS value)	12	volts
Phase angle between grid No.3 and grid No.5 voltages	90	degrees
Plate current	0.28	ma
Grid No.2, 4 and 6 current	1.5	ma
Grid No.3 current	0.09	ma
Grid No.5 current	0.03	ma
Plate resistance	5	megohms

Operating conditions as A.F. amplifier (see fig. 3)

Plate supply voltage	250	volts	
Plate load resistance	0.47	megohm	
Resistance R1	34,000	ohms	
Resistance R2	3,900	ohms	
Resistance R3	560	ohms	
Plate current	0.275	ma	
Grid No.1 input voltage (RMS value)	0.1	volt	
Output voltage (RMS value)	15	volts	
A.F. voltage gain	150		2)
Total harmonic distortion	2.8	%	

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1) The maximum value of this resistance is 22 megohms when the grid bias is only obtained by the voltage drop across the grid leak.

2) In circuits with a 5% speaker this tube may be used without special precautions against microphonic effect, if the input voltage for an output of 50 milli-watts of the power tube exceeds 25 milli-volts.

Application

The enneode 6BE7 is a noval 7-grid tube designed primarily to fulfil the combined functions of limiter, F.M. detector and A.F. amplifier in F.M. and A.M./F.M. receivers. A basic circuit with the 6BE7 for the above mentioned applications is given in fig. 1. The screen-grid voltage is about 20 volts and the control-grid voltage about -4.4 volts with respect to the cathode.

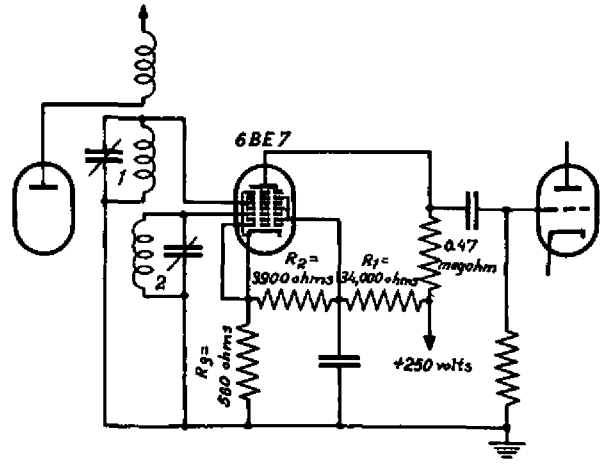

fig. 1.

The circuits of an I.F. transformer supply the signal voltages to the grids No.3 and No.5. If the frequency of the signal corresponds to the resonant frequency of the I.F. transformer the phase angle between these voltages will be 90 degrees; during modulation this phase angle varies with the frequency. The variation of the phase angle does not depend linearly on the frequency; in fact this angle will vary according to an arc cot line, but the degree of the phase variation depends on the relative frequency deviation and the quality of the secondary circuit of the I.F. transformer. Fig. 2 depicts the phase angle as a function of $Q_2 \Delta f/f$, Q_2 being the quality factor of the secondary circuit, Δf the frequency deviation and f the mean value of the signal frequency. In this figure the curve which gives the total distortion D in the A.F. plate current due to the non-linear course of the phase angle has also been plotted. If the intermediate frequency f of the receiver and the maximum frequency deviation Δf are given, the distortion which occurs at the maximum frequency deviation can be determined by means of this curve, provided the quality factor Q_2 is known. An example may give an idea of the values occurring in practice.

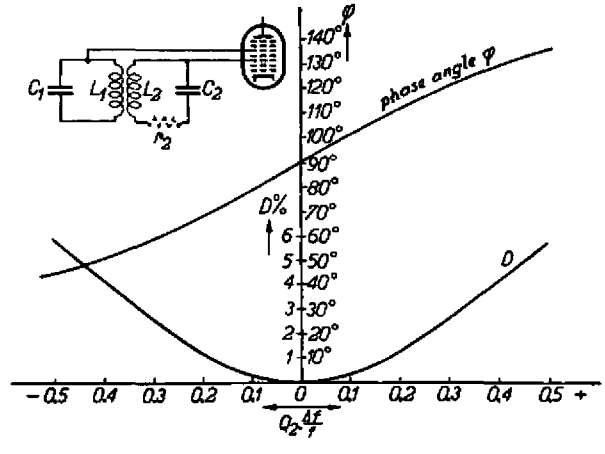

fig. 2.

If we assume f = 10 Mc/s, Δf = 75 kc/s and the permissible distortion at the maximum frequency deviation to be 2.5 %, we obtain $Q_2 \Delta f/f$=0.3, which gives Q_2= 0.3 x 10/0.075 = 40.
A distortion of 2.5% will occur only if the frequency sweep is maximum which will hardly ever be the case during a transmission. It might very well be assumed, therefore, that the mean value of the frequency sweep is about 1/3 of the maximum value mentioned, i.e. 25 kc/s. The value of $Q_2 \Delta f/f$ then becomes 0.1, in which case, according to fig.2 the corresponding distortion will be about 0.3%, which is an exceedingly low value.

The phase angle between the voltages supplied by the I.F. transformer will vary between 60° and 120° at the above mentioned adjustment and maximum frequency sweep. Curve D gives the mean value of the plate current as a function of the phase angle φ between the signal voltages. In order to obtain efficient limitation, the signal voltages should have an RMS value of at least 8 volts. Curve C shows that the plate current remains practically constant if the input voltages are further increased, which is a requirement for efficient limitation. It further appears that the mean value of the plate current is 0.28 ma and that this value fluctuates between 0.2 and 0.35 ma at a variation of the phase angle between 60° and 120°. If the variation of the phase angle is sinusoidal the RMS value of the A.C. plate current will thus be

$$\frac{0.35 - 0.2}{2\sqrt{2}} = 0.0535 \text{ ma.}$$

The enneode 6BE7 has properties similar to those of a pentode; the plate resistance actually exceeds 5 megohms. If a coupling resistor of 0.4 megohm is included in the plate circuit the RMS value of the A.F. voltage across this resistor will be 21.4 volts at a total phase sweep from 60° to 120°. Since, however, the coupling resistor is usually followed by a coupling circuit for the power output tube, the value of the plate impedance will be lower and an average output voltage of about 16 volts (RMS value) may be expected.
This output voltage is ample for complete modulation of a power tube such as the 6M5, for which an A.C. grid voltage of 4.8 volts (RMS value) is sufficient. Moderate negative feed-back may therefore be applied across this stage.
The basic circuit as A.F. amplifier is shown in fig. 3. For this application the grids No. 2, 3, 4, 5 and 6 are connected together, whilst grid No.1 serves as control grid.

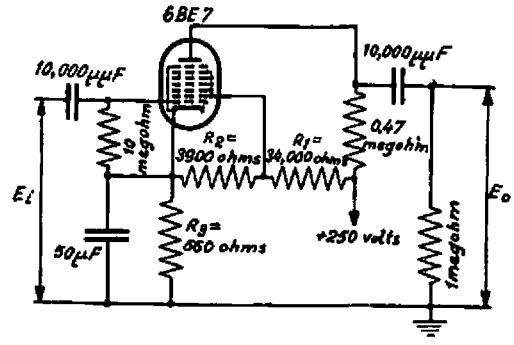

fig. 3.

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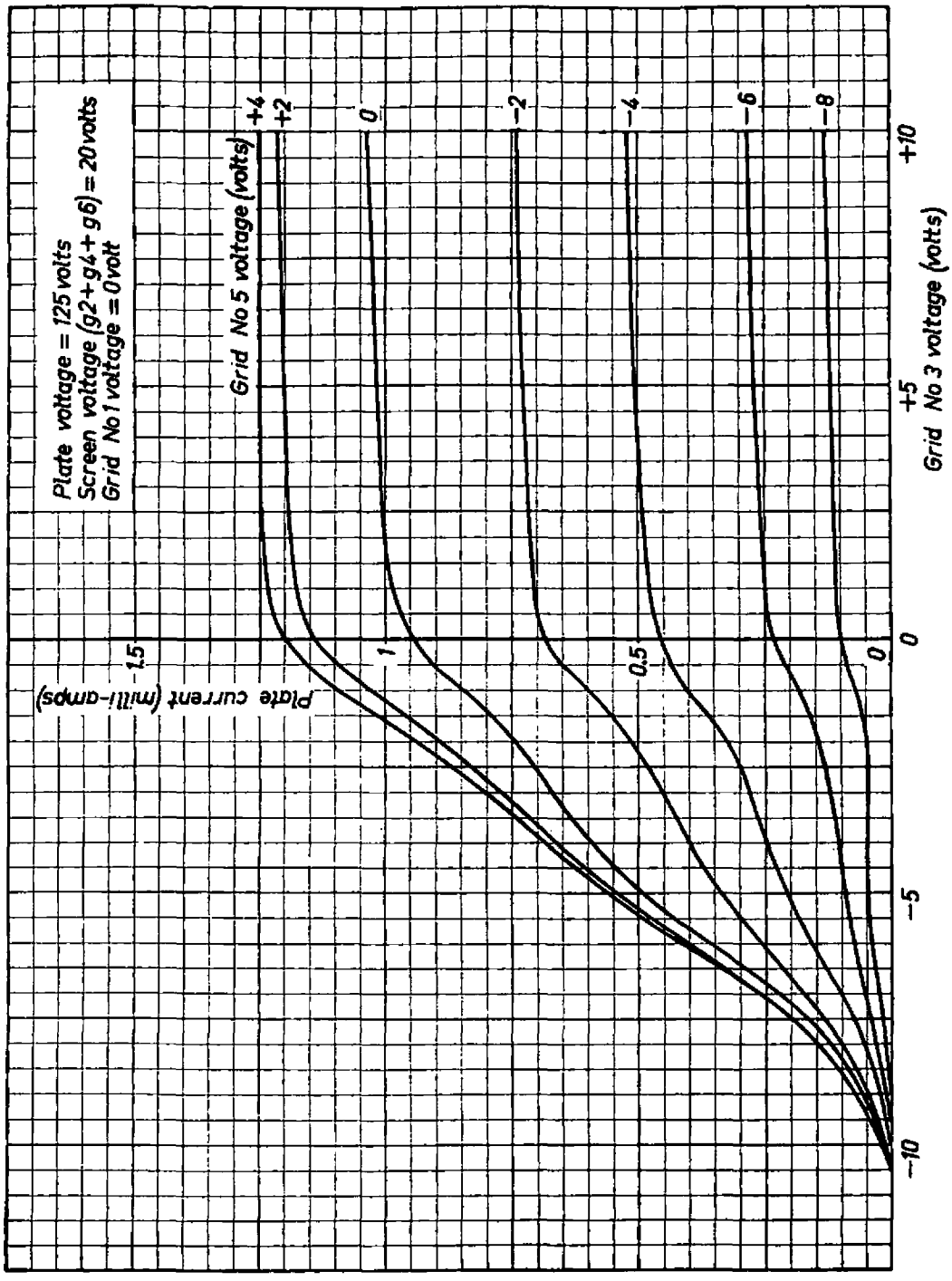
Plate voltage = 125 volts
Screen voltage (g2+g4+g6) = 20 volts
Grid No 1 voltage = 0 volt
Grid No 5 voltage (volts)
+4
+2
0
−2
−4
−6
−8
Plate current (milli-amps)
1.5
1
0.5
0
−10
−5
0
+5
+10
Grid No 3 voltage (volts)

A

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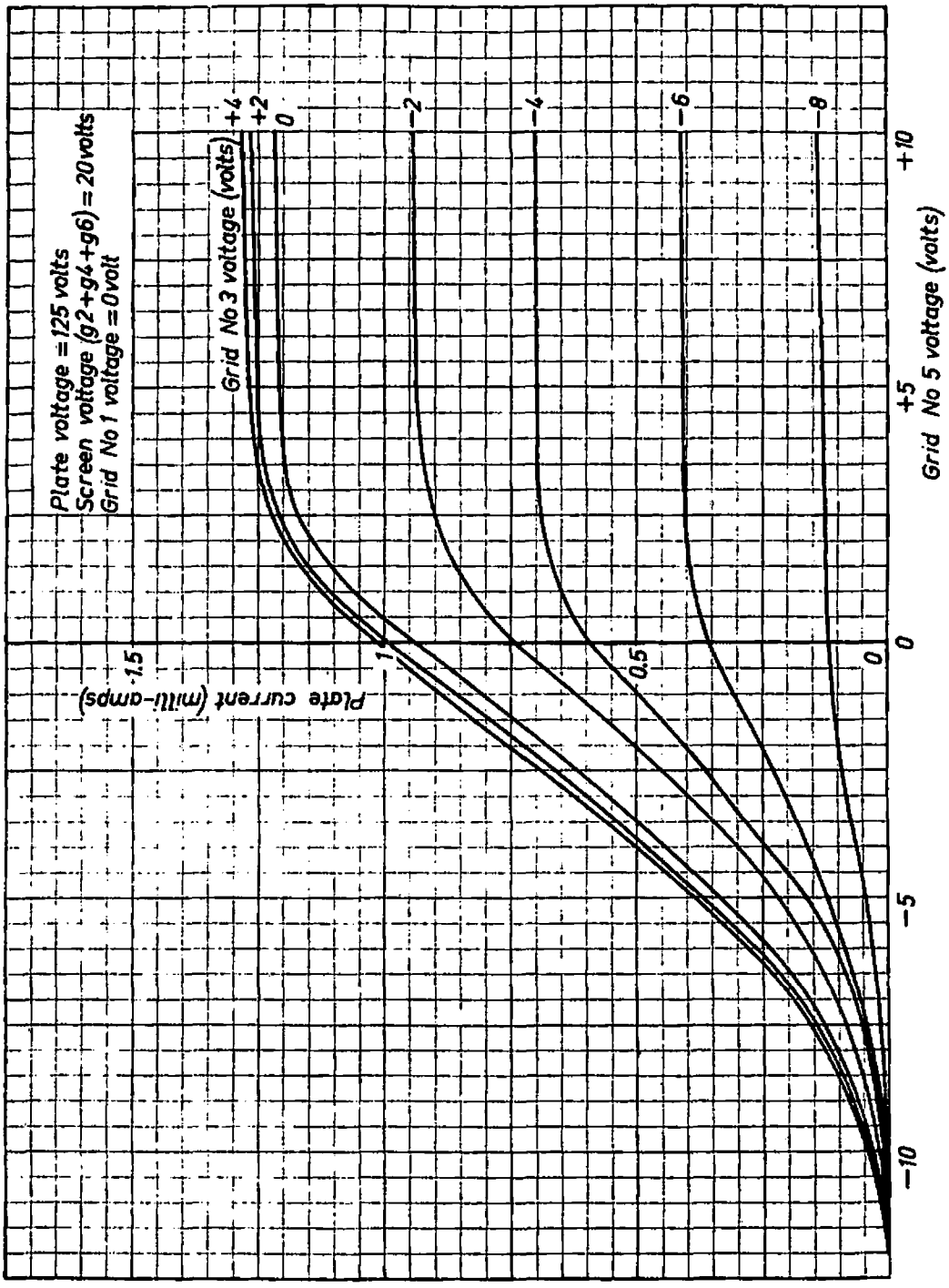
Plate voltage = 125 volts
Screen voltage (g2+g4+g6) = 20 volts
Grid No 1 voltage = 0 volt
Grid No 3 voltage (volts)
+4
+2
0
−2
−4
−6
−8
Plate current (milli-amps)
1.5
1
0.5
0
−10
−5
0
+5
+10
Grid No 5 voltage (volts)

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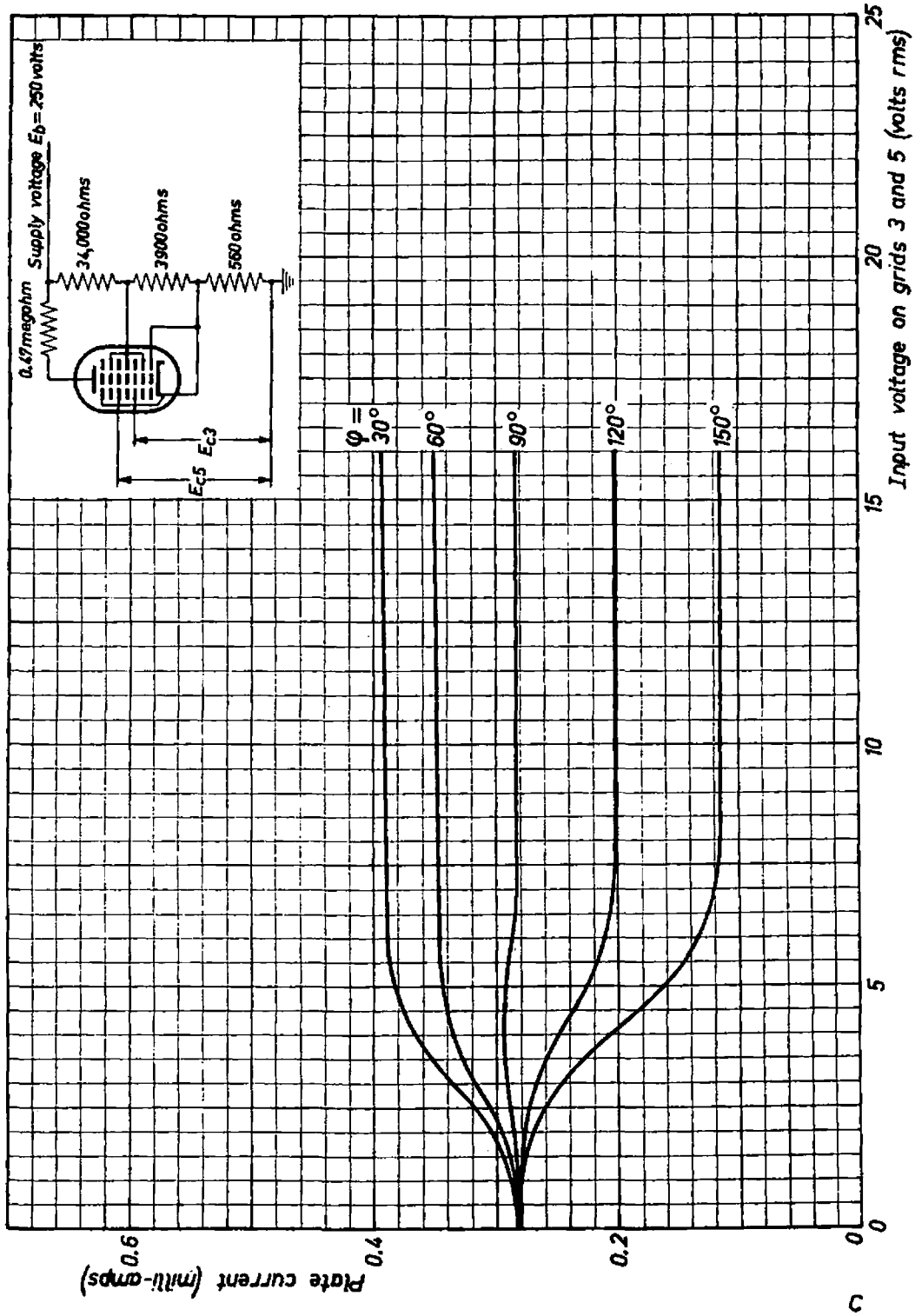
0.47megohm
Supply voltage E_b = 250 volts
34,000ohms
3900ohms
560ohms
E_{c5}
E_{c3}
φ = 30°
60°
90°
120°
150°
Input voltage on grids 3 and 5 (volts rms)
Plate current (milli-amps)
0
5
10
15
20
25
0.2
0.4
0.6

C

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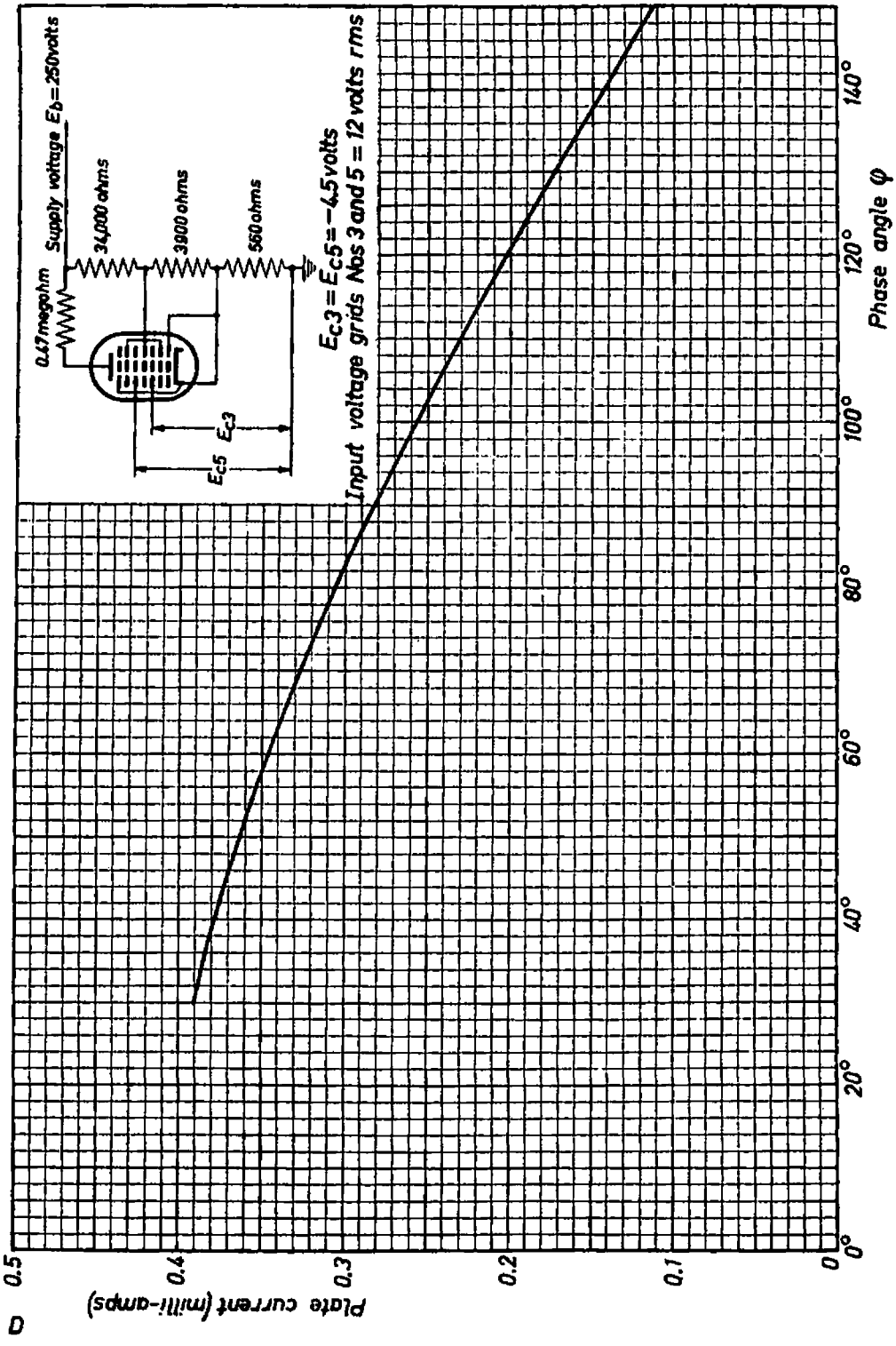
0.47 megohm
Supply voltage E_b=250 volts
34,000 ohms
3900 ohms
560 ohms
E_{c5}
E_{c3}
$E_{c3}=E_{c5}=-4.5$ volts
Input voltage grids Nos 3 and 5 = 12 volts rms
Plate current (milli-amps)
0.5
0.4
0.3
0.2
0.1
0
0°
20°
40°
60°
80°
100°
120°
140°
Phase angle φ

D

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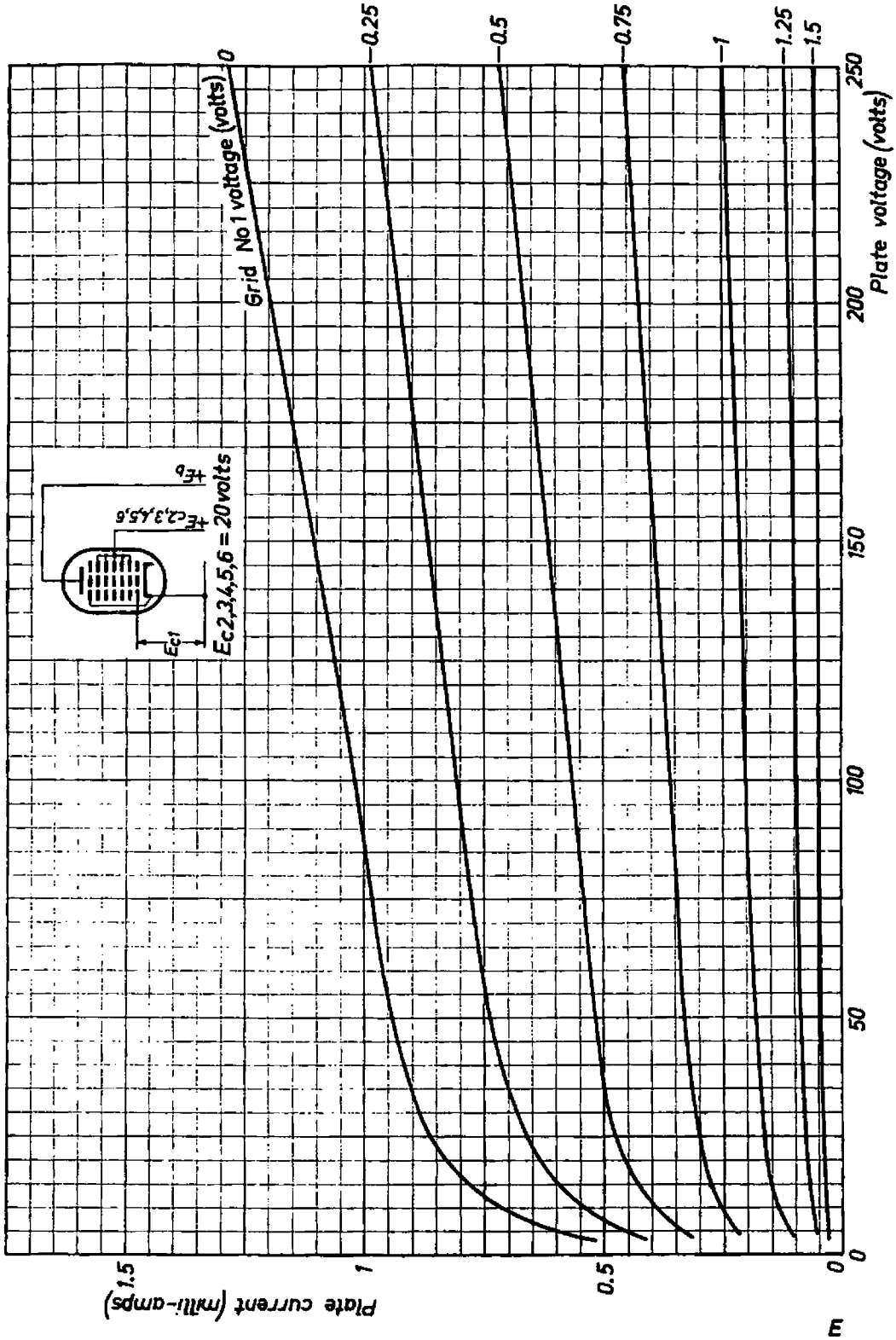
Plate current (milli-amps)
1.5
1
0.5
0
0
50
100
150
200
250
Plate voltage (volts)
Grid No 1 voltage (volts)
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
Ec2,3,4,5,6 = 20 volts
Ec1
+Ec2,3,4,5,6
+Eb

E