CHAPTER IV

EXPERIMENTAL RESUIT AND DISCUSSIONS

4.1 Dependence of Brightness on Frequency.

The brightness vs. frequency of the applied voltage, which is kept constant, is plotted as in Fig. 4.2, 4.3, 4.4 and 4.5 It is possible to see from the curve that the brightness increases as the frequencies increase, until a maximum brightness is attained, then the brightness decreases as the frequency is further increased.

4.2. Dependence of Brightness on Voltage.

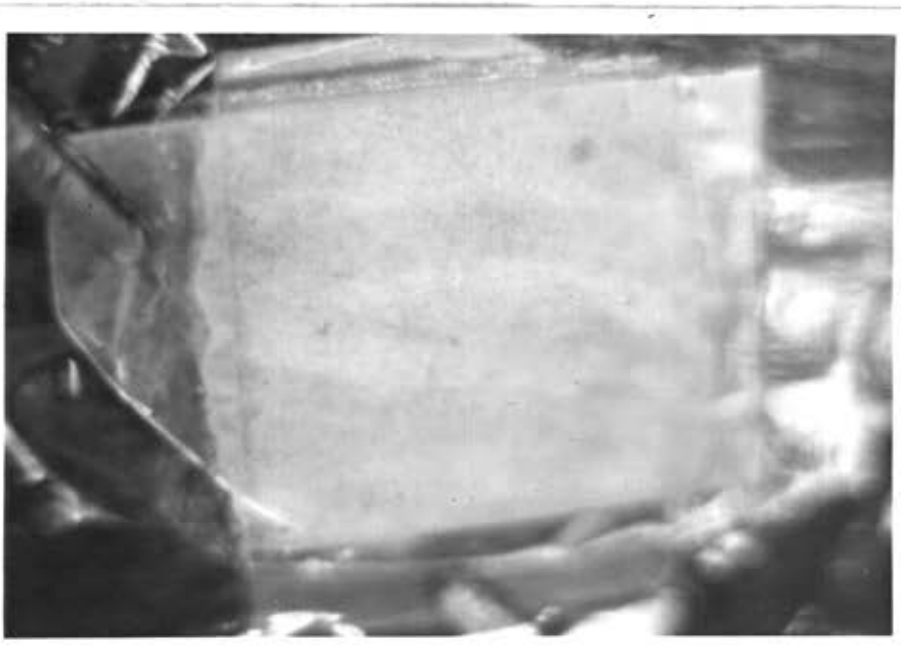
The brightness vs. voltage of EL cell. No I, and II, as shown in Fig. 4.6 a - d and Fig. 4.7 a -d indicated that there is no apparent voltage threshold, but that the light emission rises continuously from zero. All points yield a good straight line for a plot of log. I vs. $\frac{1}{\sqrt{V}}$ (I = brightness, V = voltage) as shown in Fig 4.8 a - d and 4.9 a - d.

The color of an EL cell changes with frequencies as shown in Fig. 4.1

4.3 Discussions.

In the process of making the transparent electrodes, the glass plates must be really cleaned. The heating temperature was kept between 550°and 650°c, otherwise they will be bent at higher temperature and the surface of the glass plates were not plane. The stannic chloride solution was suitably used for making the plates electrically conductive. The solution was dilute by water in the proportion of 1.5 : 1 by volume so that it was convenient for spraying. But if the too concentrated solution was used it would precipitate after a few sprayings. For very dilute solution, it gave poor conducting plates or it took many sprayings. By spraying on the 550° - 650°c

Frequency = 20,000 c.p.s.



Frequency = 5,000 c.p.s.

Fig. 4.1 Colour of the Electroluminescent Cell Changes with Frequency.

Table 4 - 1

Arbitary Units Brightness Dependence on Frequency

of Electroluminescent Cell No. I.

f Frequency in cm.	Deflection in cm.						
	100 volts	125 volts	150 volts	175 volts	200 volts	225 volts	250 volts
20,000	0.4	1.9	6.4	13.4	25.0	55.5	66.0
18,000	0.4	2.1	6.5	14.3	28.2	60.0	72.5
16,000	0.4	2.3	6.8	15.2	29.5	63.5	77.0
14,000	0.5	2.4	7.4	15.6	31.7	65.5	82.5
12,000	0.5	2.5	7.9	16.5	33.2	67.0	87.5
10,000	0.6	2.8	8.4	16.7	35.8	68.0	92.0
8,000	0.7	3.0	8.8	17.4	36.9	70.0	97.5
6,000	0.8	3.2	9.4	17.9	38.3	68.5	97.0
4,000	0.8	3.5	9.9	18.0	38.4	65.0	92.0
2,000	1.0	3.8	10.3	17.8	36.9	59.0	82.0
1,800	1.0	3.7	9.6	17.6	34.8	54.0	77.0
1,600	1.0	3.7	9.6	17.4	34.4	52.5	75.0
1,400	1.0	3.7	9.5	17.3	32.8	49.0	72.0
1,200	1.0	3.6	9.3	17.0	31.8	46.0	68.0
1,000	1.0	3.5	8.8	16.6	29.6	44.0	62.0
800	1.0	3.5	8.5	16.1	28.0	41.0	58.5
600	1.0	3.3	8.2	15.3	25.5	37.0	52.0
400	0.9	3.2	7.3	13.8	21.6	32.0	45.0
200	0.8	2.8	5.8	10.8	16.6	24.5	33.5
180	0.8	2.6	5.3	9.5	15.0	22.0	30.0
160	0.8	2.5	5.0	9.1	14.5	21.0	28.0
140	0.8	2.3	4.8	8.7	13.5	20.0	26.5
120	0.8	2.3	4.5	8.0	12.6	18.5	24.5
100	0.8	2.2	4.2	7.4	11.5	16.5	22.5

Table 4 - 2

Arbitary Units Brightness Dependence on Frequency

of Electroluminescent Cell No. II.

f Frequency in cm.	Deflection in cm.						
	100 volts	125 volts	150 volts	175 volts	200 volts	225 volts	250 volts
20,000	0.09	0.40	1.30	3.30	7.20	15.00	25.80
18,000	0.09	0.48	1.45	3.75	8.10	15.80	27.40
16,000	0.10	0.50	1.55	4.00	8.80	17.40	29.40
14,000	0.10	0.51	1.70	4.45	9.50	18.40	31.60
12,000	0.10	0.55	1.90	4.80	10.10	19.50	33.70
10,000	0.15	0.65	2.10	5.30	10.60	20.70	36.50
8,000	0.19	0.80	2.25	5.50	11.50	21.80	39.55
6,000	0.20	0.85	2.50	5.90	12.00	22.50	39.80
4,000	0.20	0.95	2.50	6.00	11.90	22.30	38.00
2,000	0.25	0.97	2.64	5.80	11.10	20.60	33.40
1,800	0.25	0.97	2.60	5.80	10.90	20.00	33.00
1,600	0.25	0.99	2.60	5.95	10.65	19.40	31.80
1,400	0.27	0.99	2.50	5.80	10.40	18.75	30.50
1,200	0.27	0.99	2.48	5.60	10.20	18.00	28.80
1,000	0.27	1.00	2.45	5.45	9.90	17.60	27.35
800	0.27	0.99	2.45	5.15	9.40	16.50	25.30
600	0.25	0.91	2.25	4.80	8.80	15.20	24.10
400	0.25	0.90	2.00	4.55	7.90	13.70	21.40
200	0.20	0.81	1.75	3.80	6.85	11.60	17.20
180	0.20	0.80	1.70	3.71	6.60	11.05	16.70
160	0.20	0.80	1.70	3.70	6.60	10.50	16.20
140	0.20	0.80	1.65	3.60	6.25	10.40	15.60
120	0.20	0.75	1.60	3.40	6.00	10.10	15.10
100	0.20	0.70	1.45	3.30	5.80	9.60	14.00

Table 4 - 3

Arbitary Units Brightness Dependence on Frequency of Electroluminescent Cell No. III.

f Frequency in cm.	Deflection in cm.					
	100 volts	125 volts	150 volts	175 volts	200 volts	225 volts
20,000	0.20	0.80	2.20	5.20	10.30	19.20
18,000	0.20	0.85	2.40	5.50	11.40	19.80
16,000	0.20	0.95	2.55	6.20	11.95	20.90
14,000	0.25	1.00	2.70	6.40	12.80	21.30
12,000	0.30	1.10	3.00	6.80	13.05	23.10
10,000	0.30	1.20	3.20	7.40	13.70	23.70
8,000	0.30	1.35	3.40	7.90	14.50	24.70
6,000	0.40	1.40	3.60	8.20	15.30	25.00
4,000	0.50	1.70	4.05	8.70	15.60	25.30
2,000	0.55	1.85	4.30	8.90	15.50	23.90
1,800	0.55	1.80	4.35	8.80	15.40	23.40
1,600	0.55	1.80	4.40	8.70	15.20	23.00
1,400	0.55	1.80	4.30	8.50	15.00	22.60
1,200	0.50	1.80	4.25	8.40	14.40	21.60
1,000	0.50	1.80	4.15	8.30	13.90	20.40
800	0.50	1.75	4.05	7.80	13.10	18.90
600	0.50	1.65	3.70	7.20	11.90	17.30
400	0.50	1.50	3.40	6.40	10.40	15.20
200	0.40	1.35	2.70	5.00	7.90	11.10
180	0.40	1.30	2.60	4.70	7.50	10.90
160	0.40	1.25	2.50	4.50	7.30	10.60
140	0.40	1.20	2.45	4.40	6.90	9.90
120	0.40	1.10	2.30	4.10	6.50	9.50
100	0.40	1.05	2.15	3.85	6.10	8.80

Table 4 - 4

Arbitary Units Brightness Dependence on Frequency

of Electroluminescent Cell No.IV.

f Frequency in cm.	Deflection in cm.						
	100 volts	125 volts	150 volts	175 volts	200 volts	225 volts	250 volts
20,000	0.5	1.6	4.1	9.1	15.0	27.0	39.0
18,000	0.5	1.7	4.1	9.3	15.5	28.0	40.0
16,000	0.5	1.8	4.3	9.4	16.2	29.0	40.5
14,000	0.5	1.9	4.6	9.4	17.2	30.0	41.5
12,000	0.55	2.0	4.7	9.9	18.1	31.0	42.5
10,000	0.6	2.0	5.2	10.7	18.5	31.5	43.5
8,000	0.65	2.1	5.4	10.9	18.7	31.8	44.5
6,000	0.65	2.3	5.4	11.0	18.1	31.5	44.0
4,000	0.7	2.3	5.5	10.9	17.8	29.8	42.0
2,000	0.8	2.3	5.3	10.2	16.6	26.4	37.2
1,800	0.9	2.2	5.2	10.0	16.1	25.7	35.7
1,600	0.9	2.2	5.1	9.7	15.9	24.8	34.6
1,400	0.85	2.2	5.0	9.5	15.6	23.9	33.0
1,200	0.8	2.1	4.8	9.1	14.8	22.5	31.8
1,000	0.8	2.1	4.6	8.6	13.9	21.4	29.0
800	0.7	2.1	4.2	8.2	13.0	20.2	27.3
600	0.65	1.9	4.0	7.4	11.9	17.9	23.9
400	0.6	1.6	3.6	6.6	10.5	15.4	20.1
200	0.5	1.3	2.8	5.1	7.8	11.4	15.2
180	0.5	1.2	2.5	4.8	7.3	10.7	14.5
160	0.5	1.2	2.2	4.6	7.1	10.3	13.9
140	0.4	1.1	2.0	4.3	6.8	9.7	13.1
120	0.4	1.1	1.7	4.1	6.3	9.0	12.4
100	0.4	1.0	1.5	3.7	5.8	8,4	11.4

Table 4 - 5

Arbitary Units Brightness Dependence on Voltage of Electroluminescent Cell No. I.

V volt	$\frac{1}{\sqrt{V}}$	Deflection in cm.			
		f=20,000 c.p.s.	f=5,000 c.p.s.	f=500 c.p.s.	f=50 c.p.s.
80	0.1118	0.2	0.2	0.2	0.2
90	0.1055	0.3	0.5	0.4	0.4
100	0.1000	0.5	0.8	0.8	0.6
110	0.0954	1.0	1.4	1.4	0.8
120	0.0913	1.7	2.2	2.2	1.2
130	0.0877	2.7	3.5	3.2	1.7
140	0.0845	4.1	5.2	4.2	2.2
150	0.0816	6.0	7.5	6.2	2.8
160	0.0790	8.2	10.8	8.5	3.6
170	0.0767	12.0	14.9	10.8	4.6
180	0.0745	16.9	20.2	13.8	5.4
190	0.0726	22.8	25.8	17.0	6.5
200	0.0707	28.4	33.1	20.8	9.1
210	0.0690	39.1	40.9	25.6	-
220	0.0674	46.0	49.0	30.6	-

Table 4 - 6

Arbitary Units Brightness Dependence on Voltage of Electroluminescent Cell No. II.

V volt	$\frac{1}{\sqrt{V}}$	Deflection in cm.			
		f=20,000 c.p.s.	f=5,000 c.p.s.	f=500 c.p.s.	f=50 c.p.s.
80	0.1118	0.05	0.08	0.10	0.10
90	0.1055	0.10	0.15	0.18	0.15
100	0.1000	0.25	0.25	0.30	0.21
110	0.0954	0.48	0.45	0.50	0.35
120	0.0913	0.80	0.81	0.80	0.53
130	0.0877	1.30	1.30	1.20	0.70
140	0.0845	1.90	1.95	1.75	0.95
150	0.0816	2.70	2.80	2.35	1.30
160	0.0790	3.80	4.10	3.15	1.65
170	0.0767	5.10	5.70	4.20	2.10
180	0.0745	7.00	7.50	5.50	2.60
190	0.0726	8.90	10.20	6.70	3.10
200	0.0707	11.50	12.70	8.25	-
210	0.0690	14.60	16.60	10.20	-
220	0.0674	18.60	21.90	12.60	-
230	0.0659	23.00	27.30	15.00	-
240	0.0645	27.90	33.10	17.40	-
250	0.0632	33.50	41.70	28.00	-

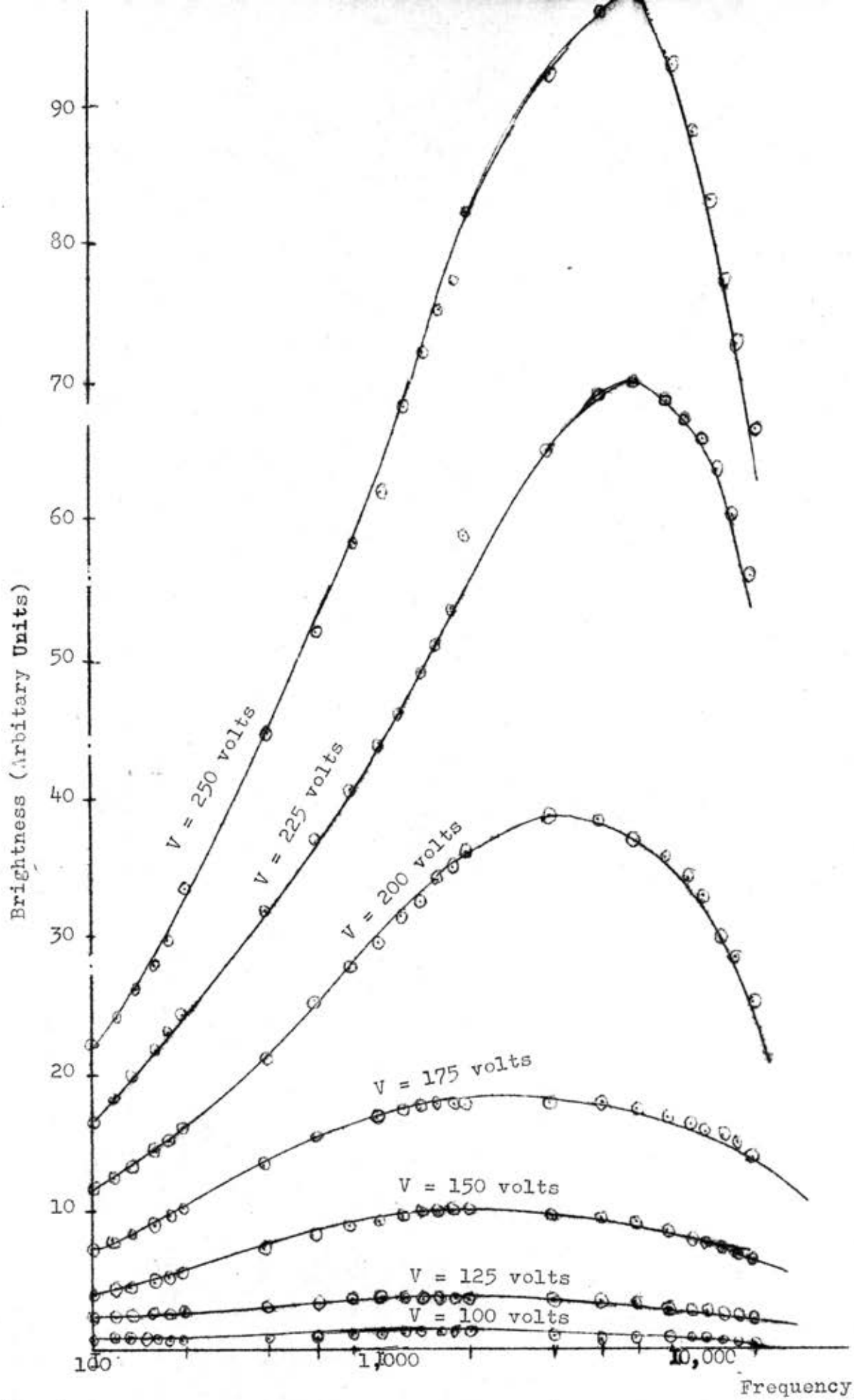


Fig. 4.2 Brightness Dependence on Frequency Applied to Electroluminescent Cell No. I

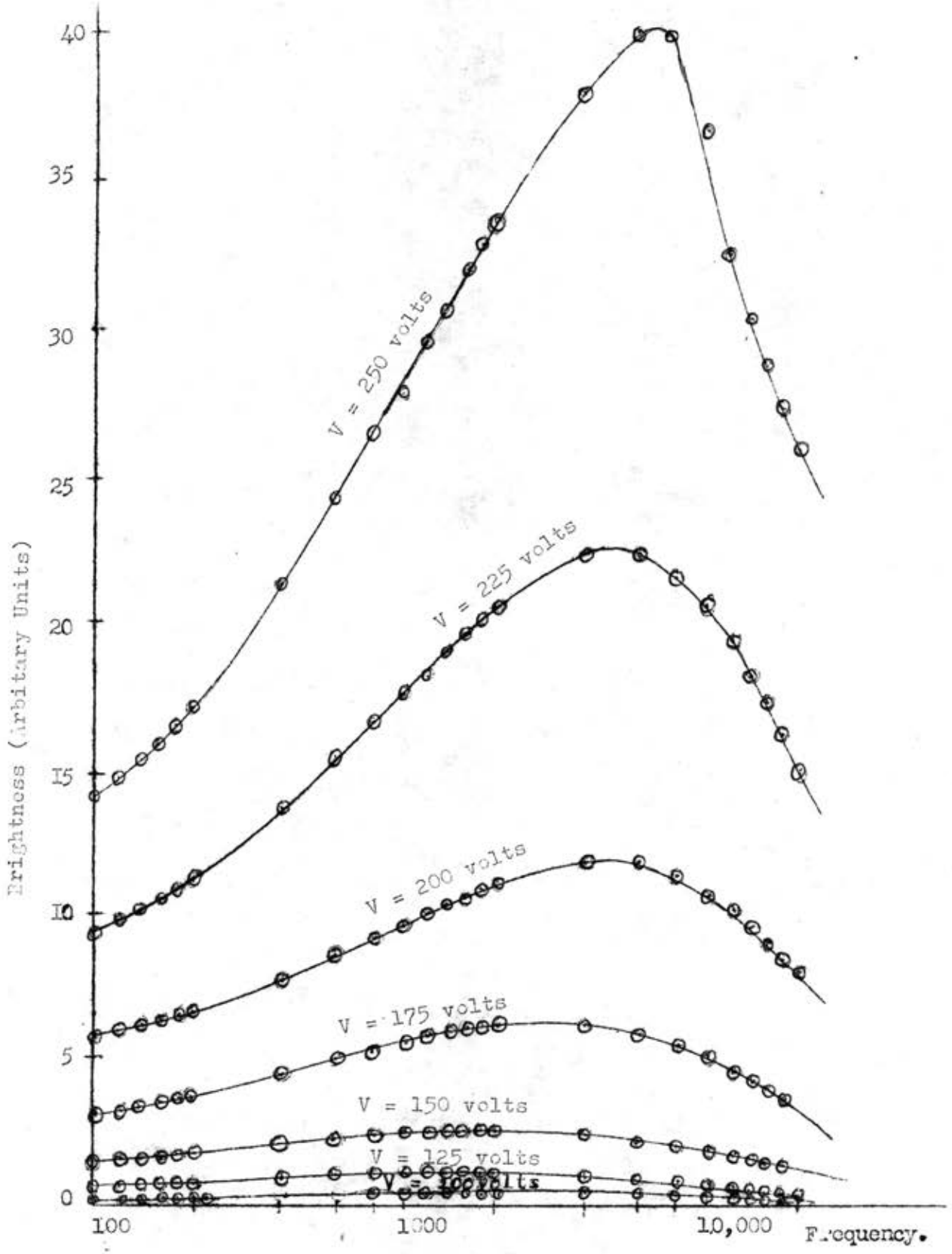


Fig. 4.3 Brightness Dependence on Frequency Applied to Electroluminescent Cell No. II.

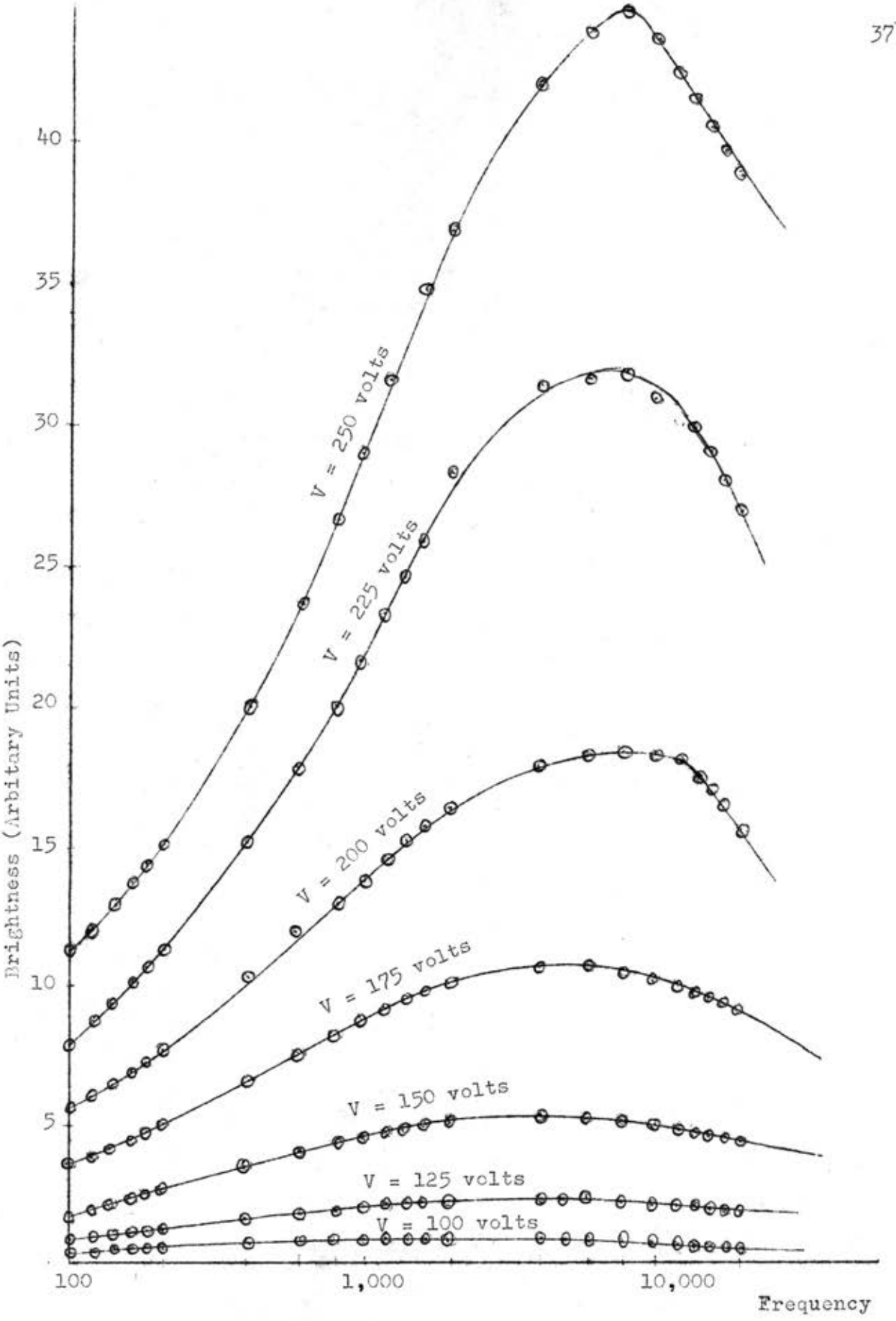


Fig. 4.4 Brightness Dependence on Frequency Applied to Electroluminescent Cell No. III.

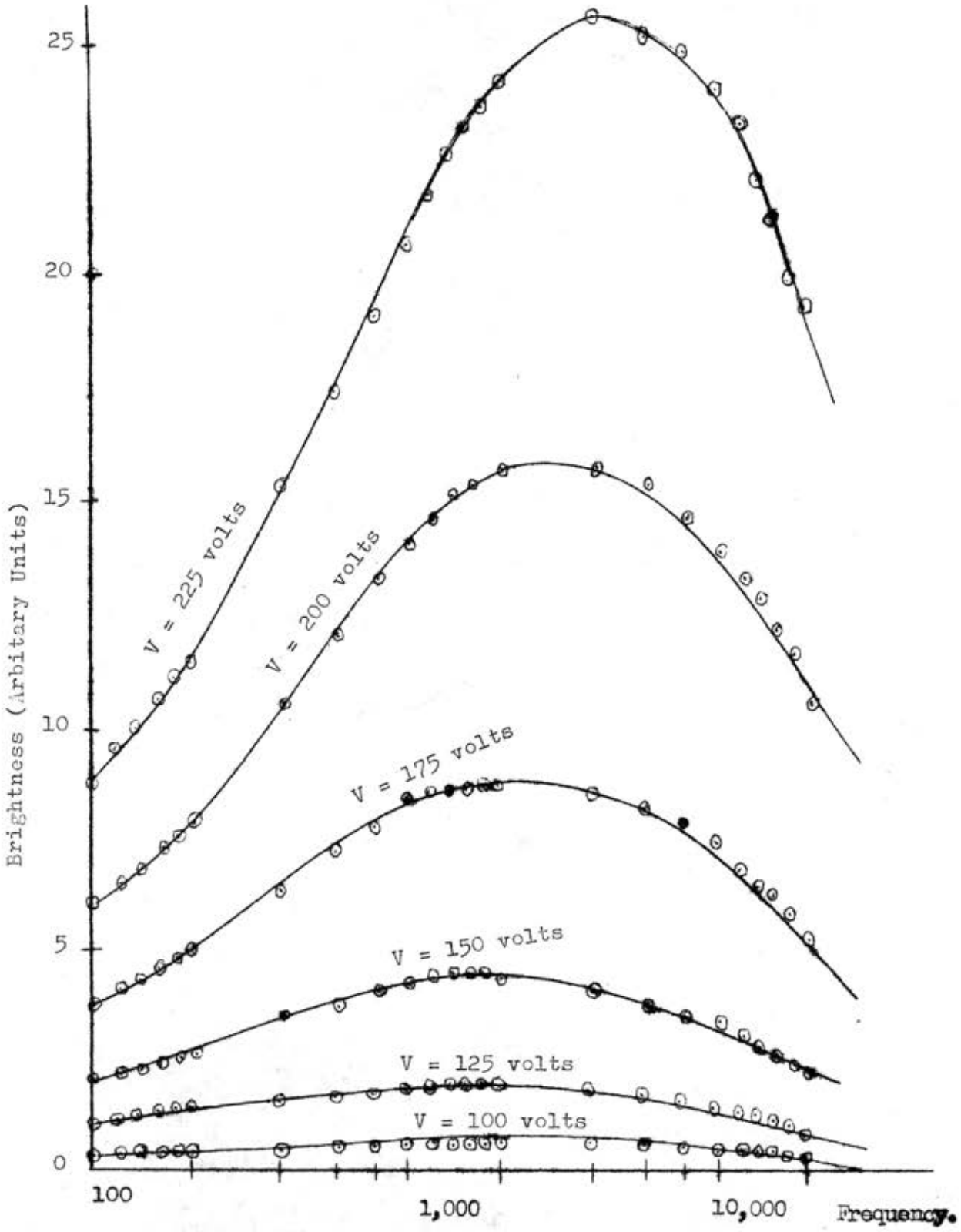


Fig. 4.5 Brightness Dependence on Frequency Applied to Electroluminescent Cell No. IV.

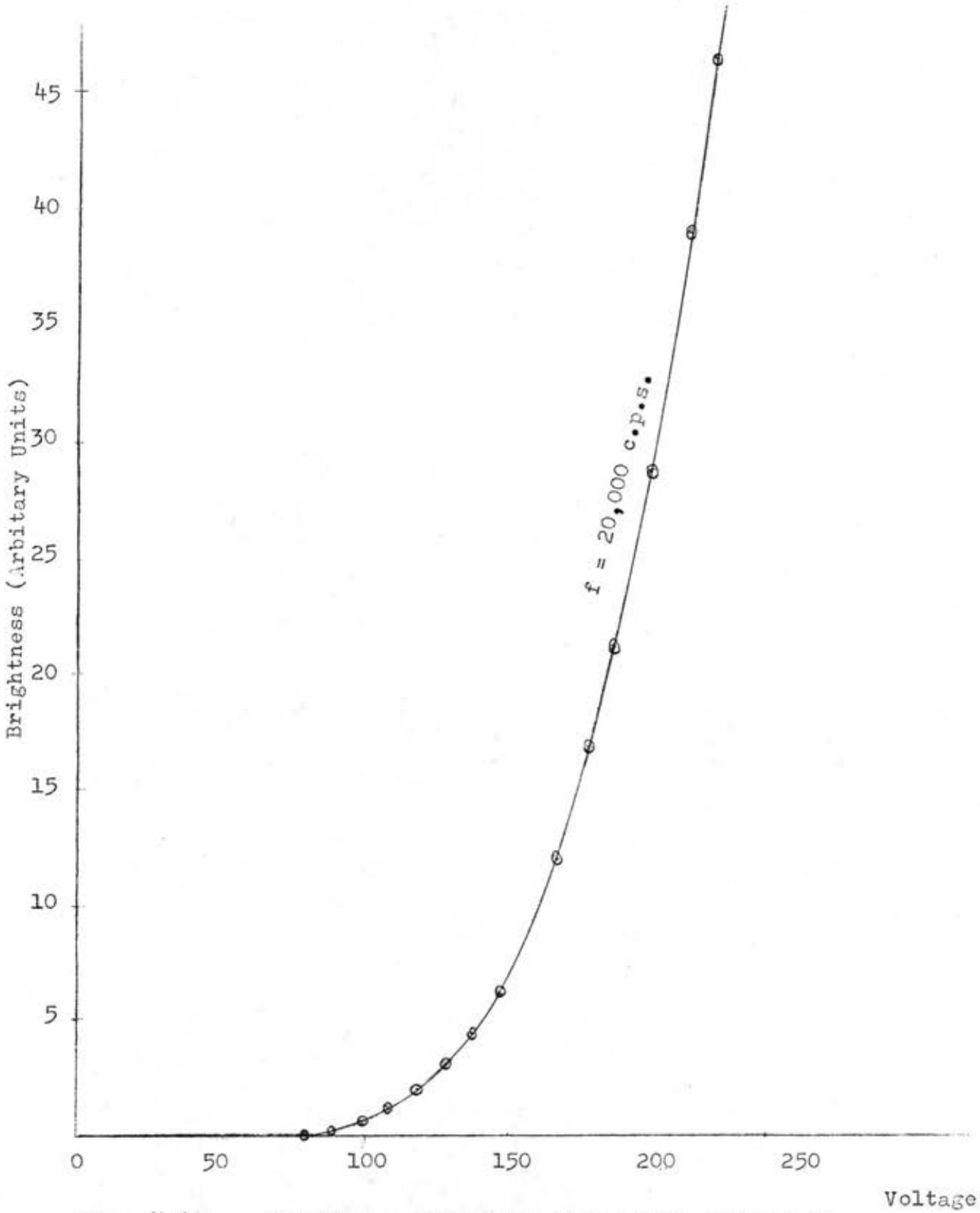


Fig. 4.6 a. Brightness Dependence on Voltage Applied to Electroluminescent Cell No. I at Frequency 20,000 c.p.s.

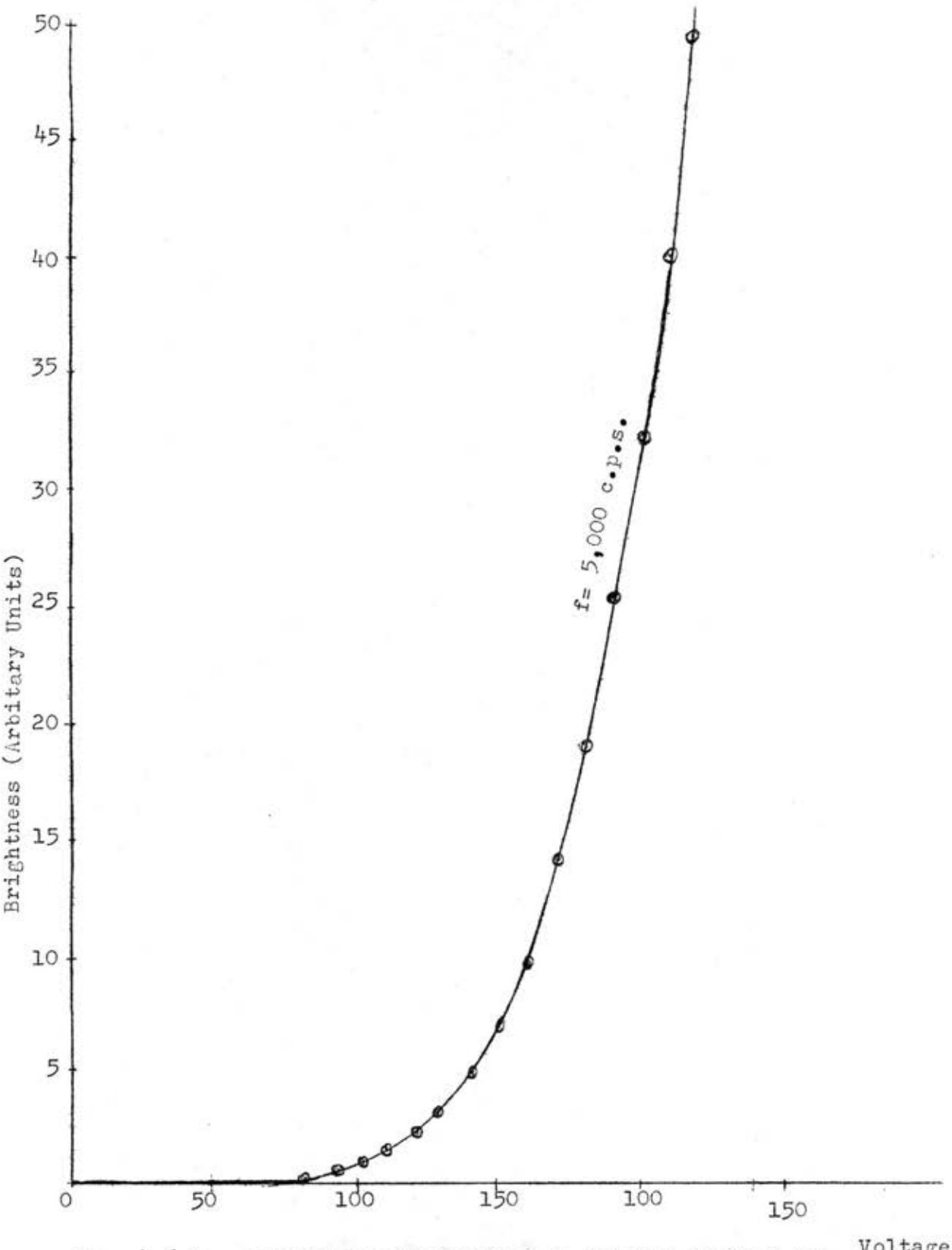


Fig. 4.6 b. Brightness Dependence on Voltage Applied to Electroluminescent Cell No. I at Frequency 5,000 c.p.s.

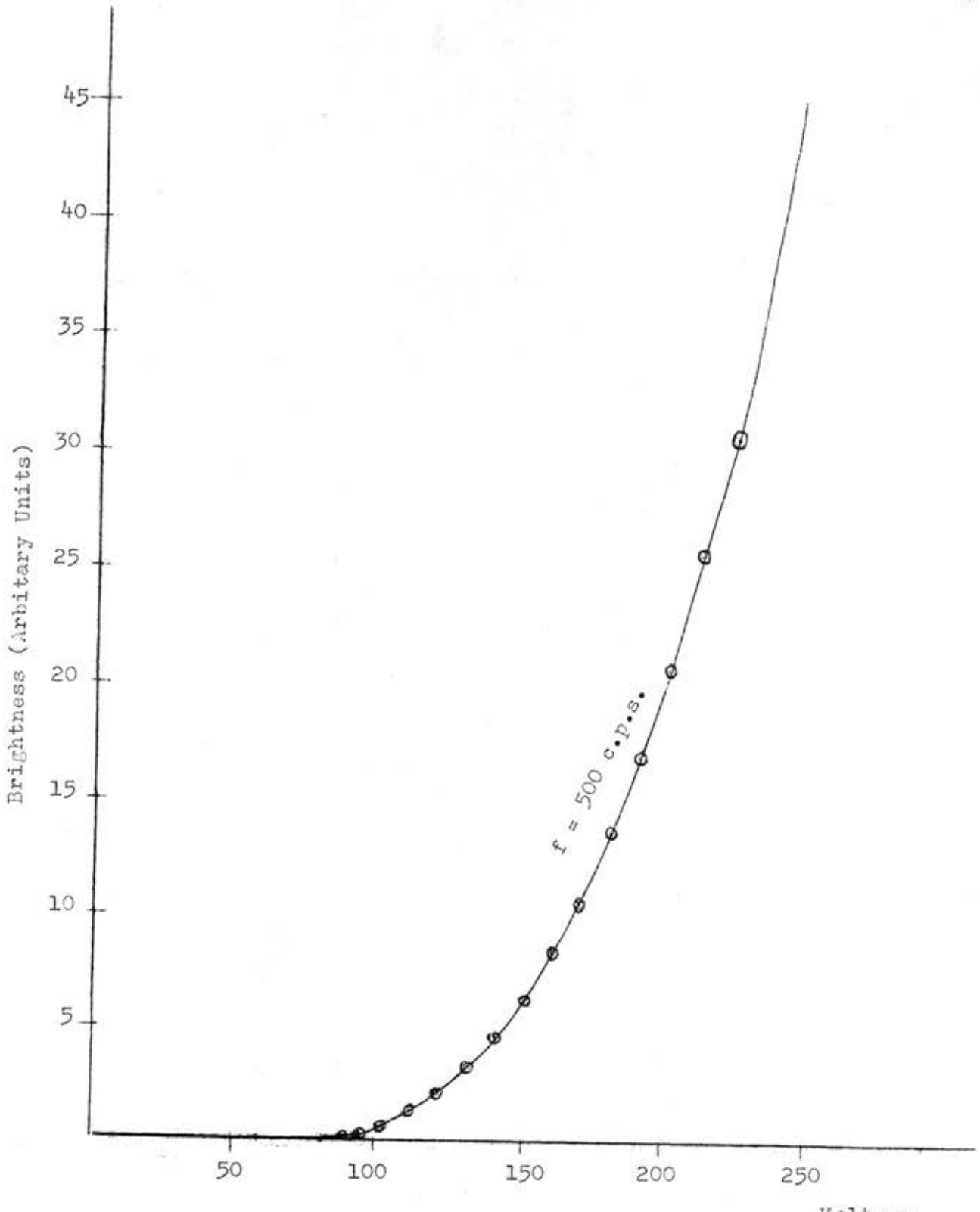


Fig. 4.6 c. Brightness Dependence on Voltage Applied to Electroluminescent Cell No. I at Frequency 500 c.p.s.

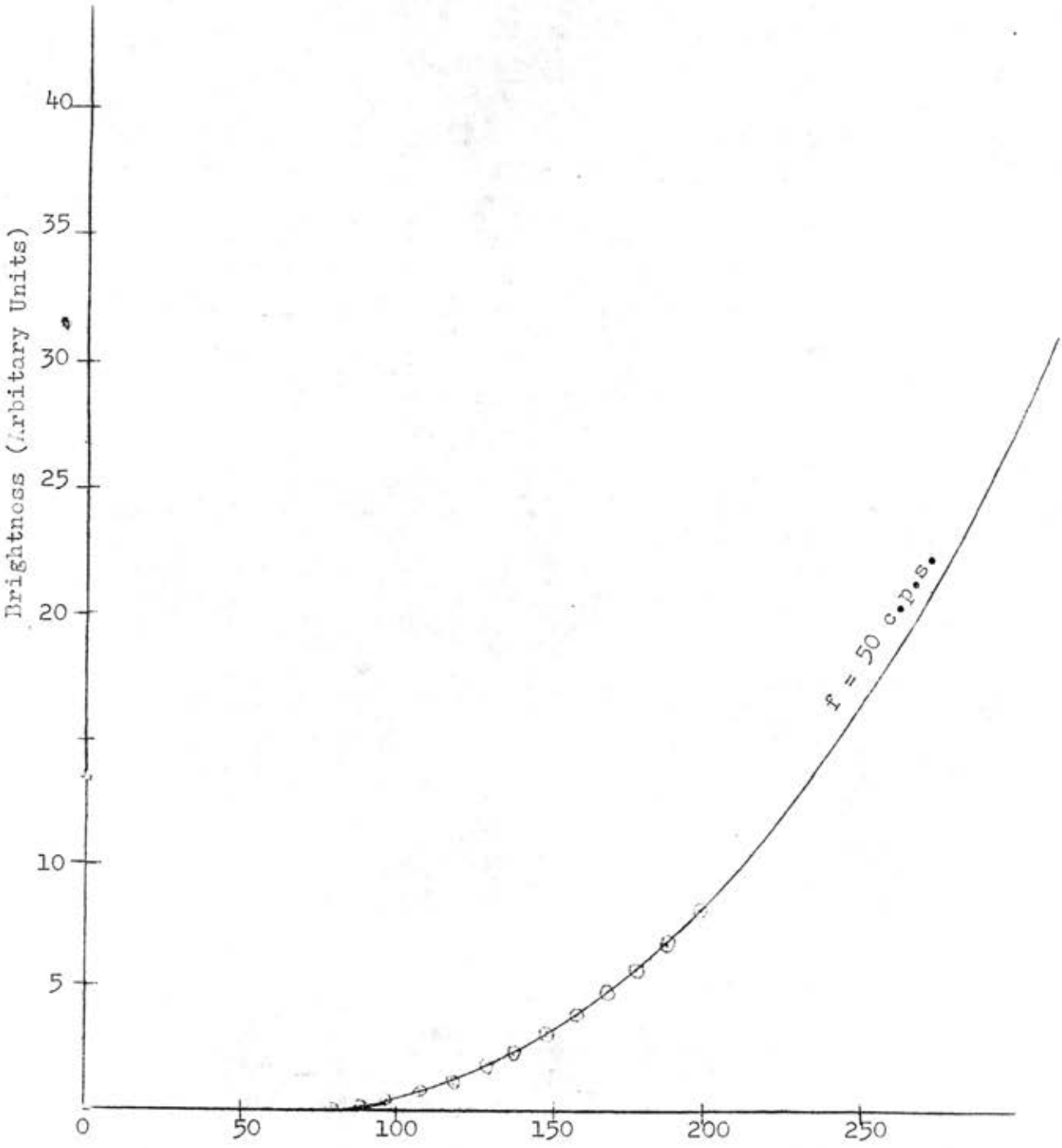


Fig. 4.6 d. Brightness Dependence on Voltage Applied to Electroluminescent Cell No. I at Frequency 50 c.p.s.

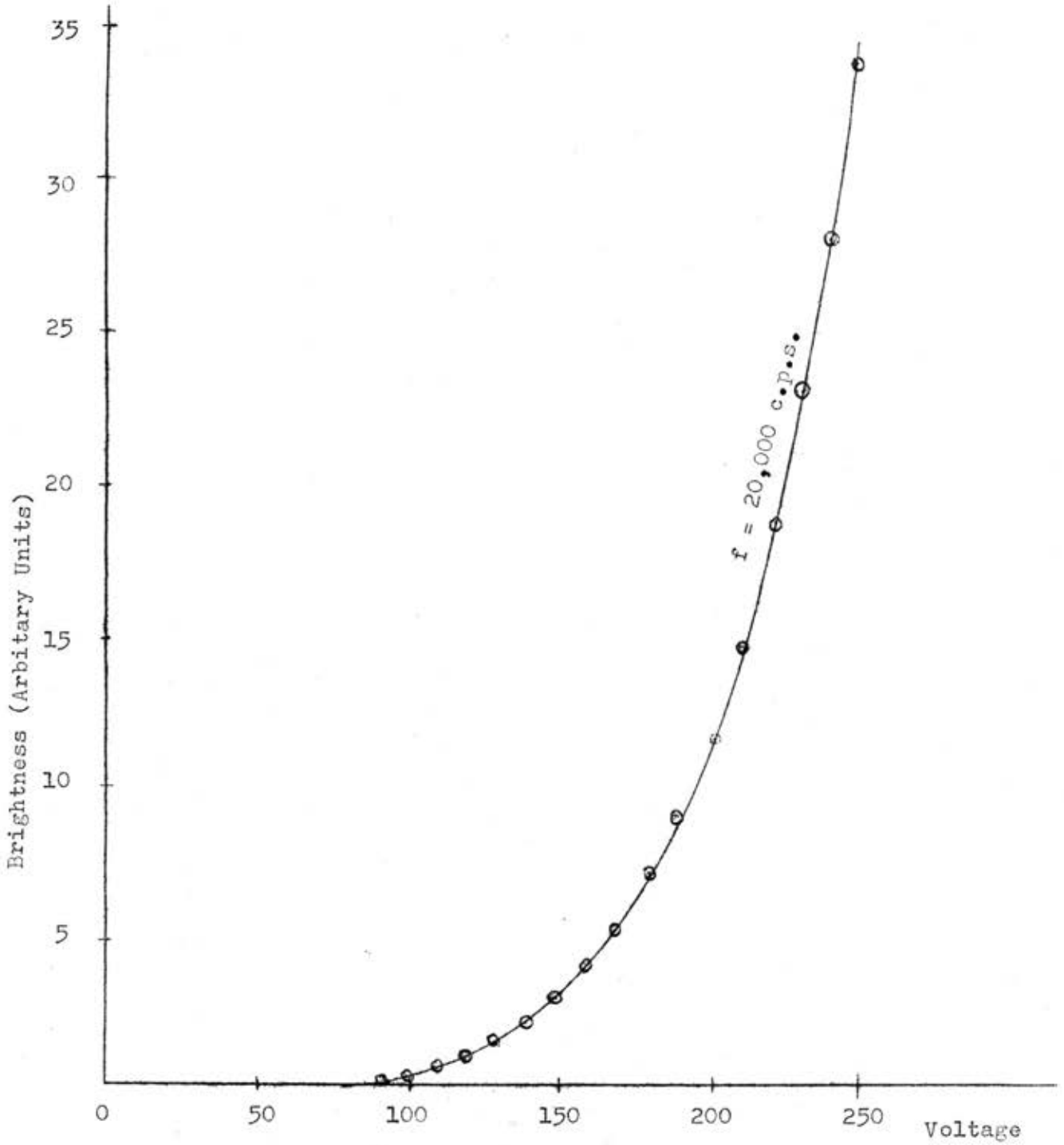


Fig. 4.7 a. Brightness Dependence on Voltage Applied to Electroluminescent Cell No. II at Frequency 20,000 c.p.s.

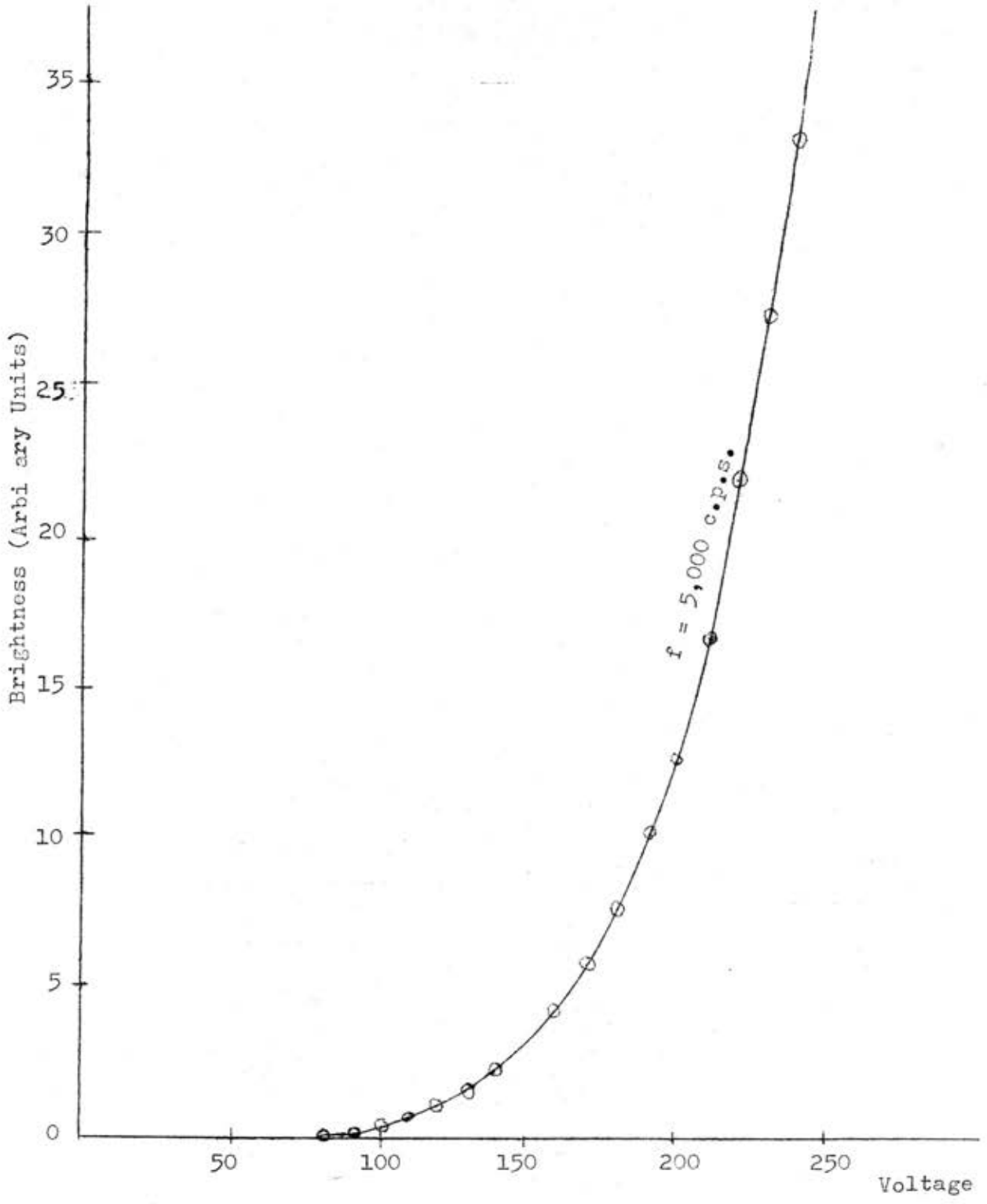


Fig. 4.7 b. Brightness Dependence on Voltage Applied to Electroluminescent Cell No. II at frequency 5,000 c.p.s.

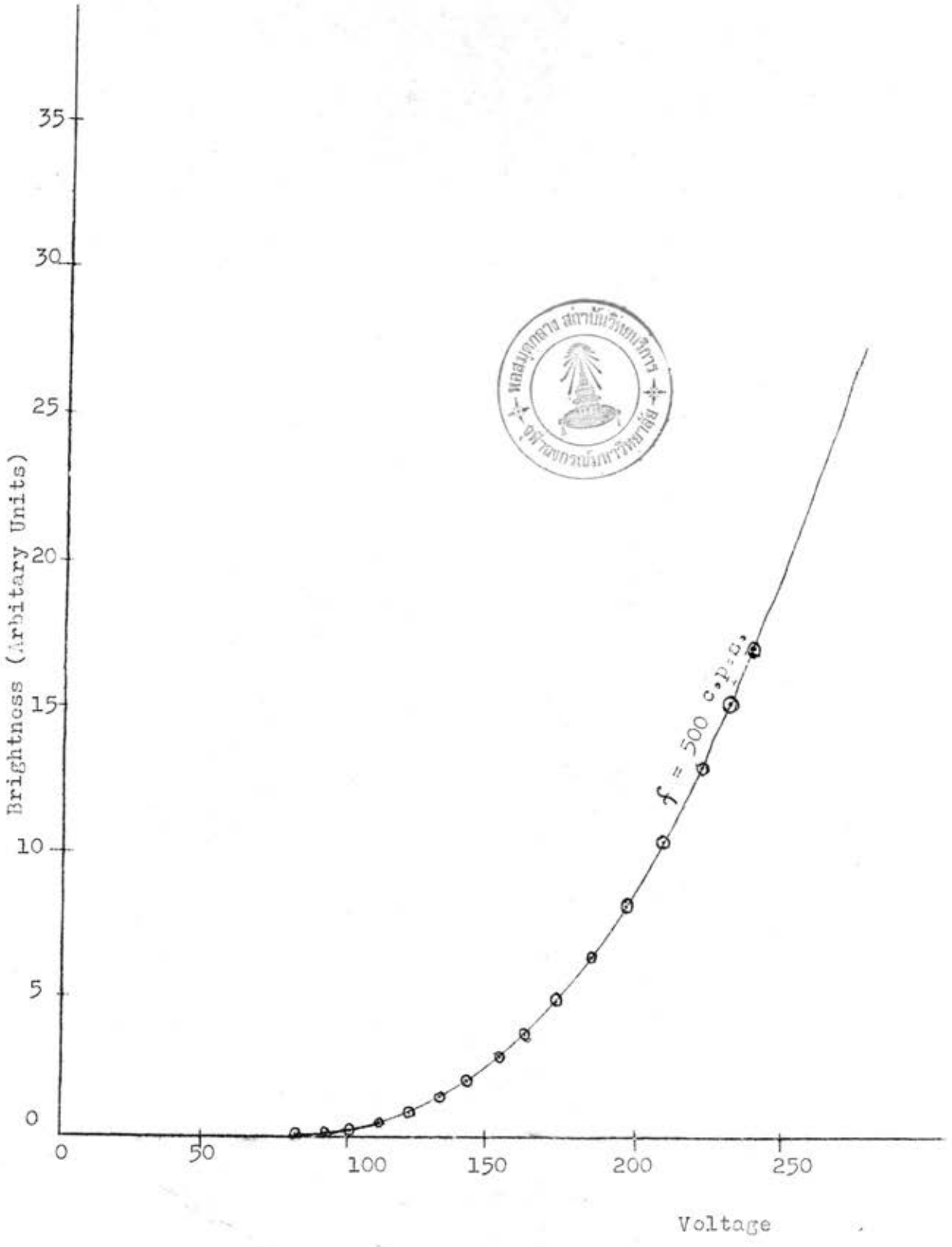


Fig. 4.7c Brightness Dependence on Voltage Applied to Electroluminescent Cell No. II at Frequency 500 c.p.s.

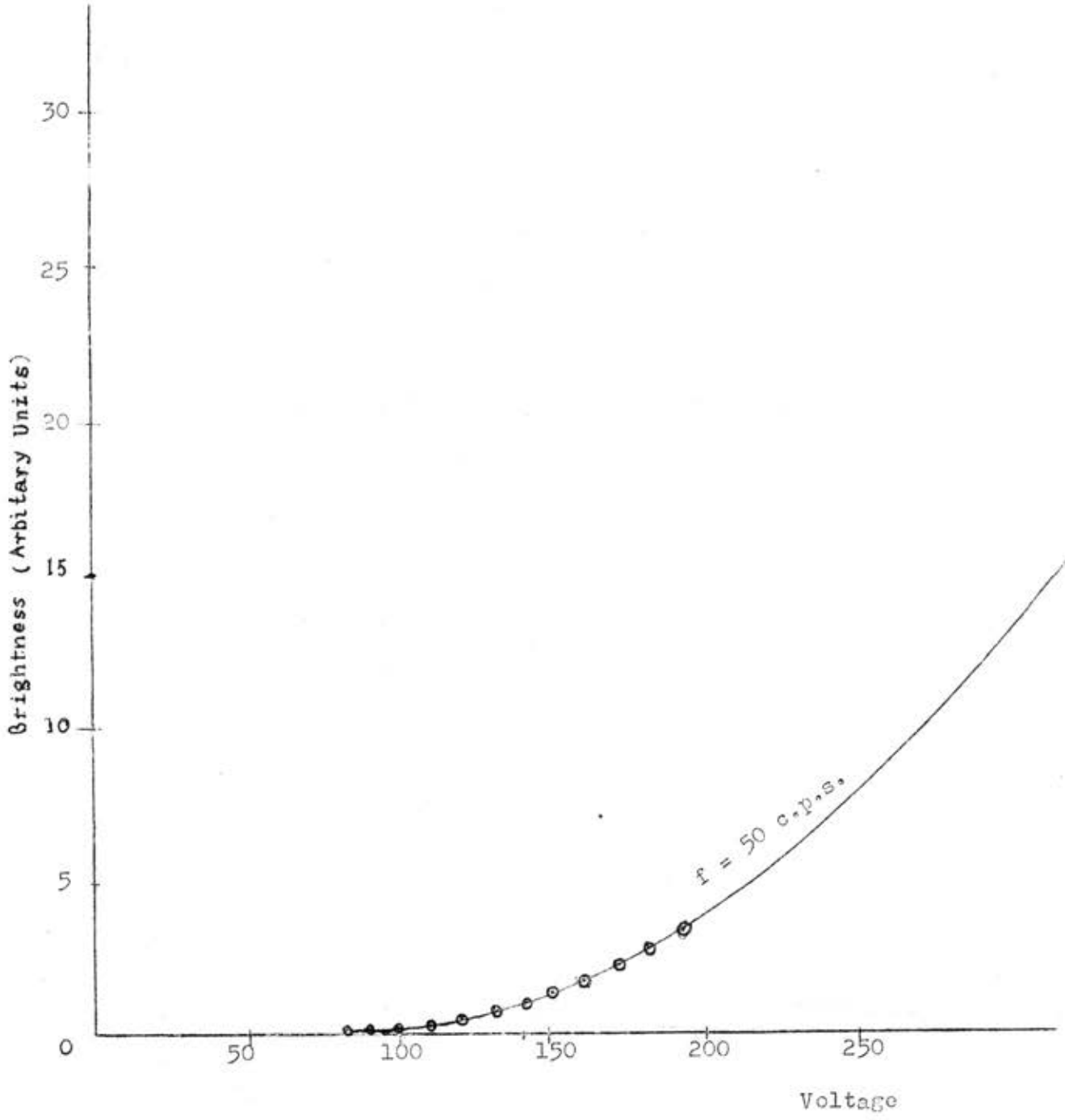


Fig 4.7 d. Brightness Dependence on Voltage Applied to Electroluminescent Cell No. II at frequency 50 c.p.s.

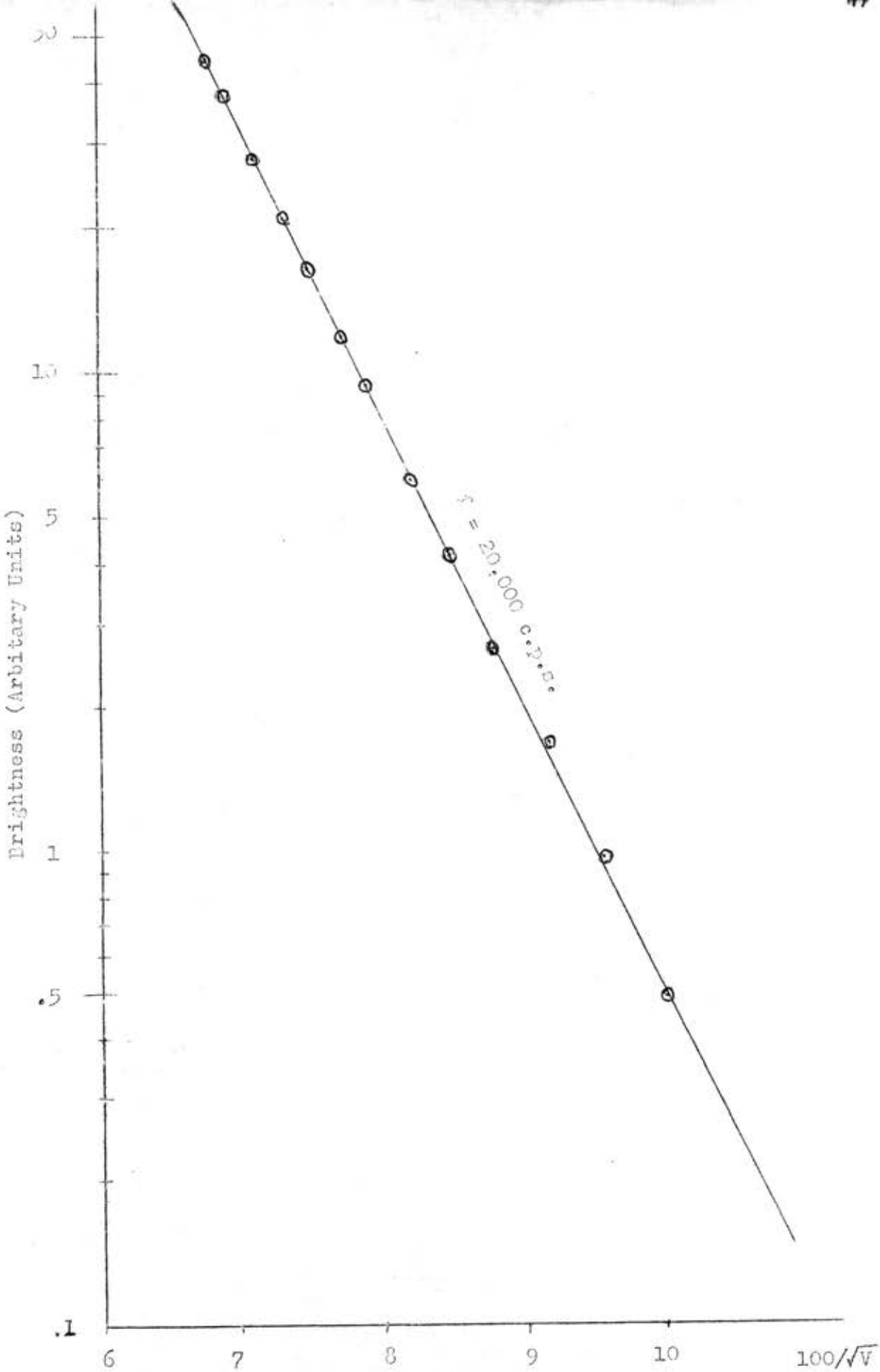


Fig. 4.8 a. Brightness Dependence on the Inverse Square Root of Voltage Applied to Electroluminescent Cell No. I at Frequency 20,000 c.p.s.

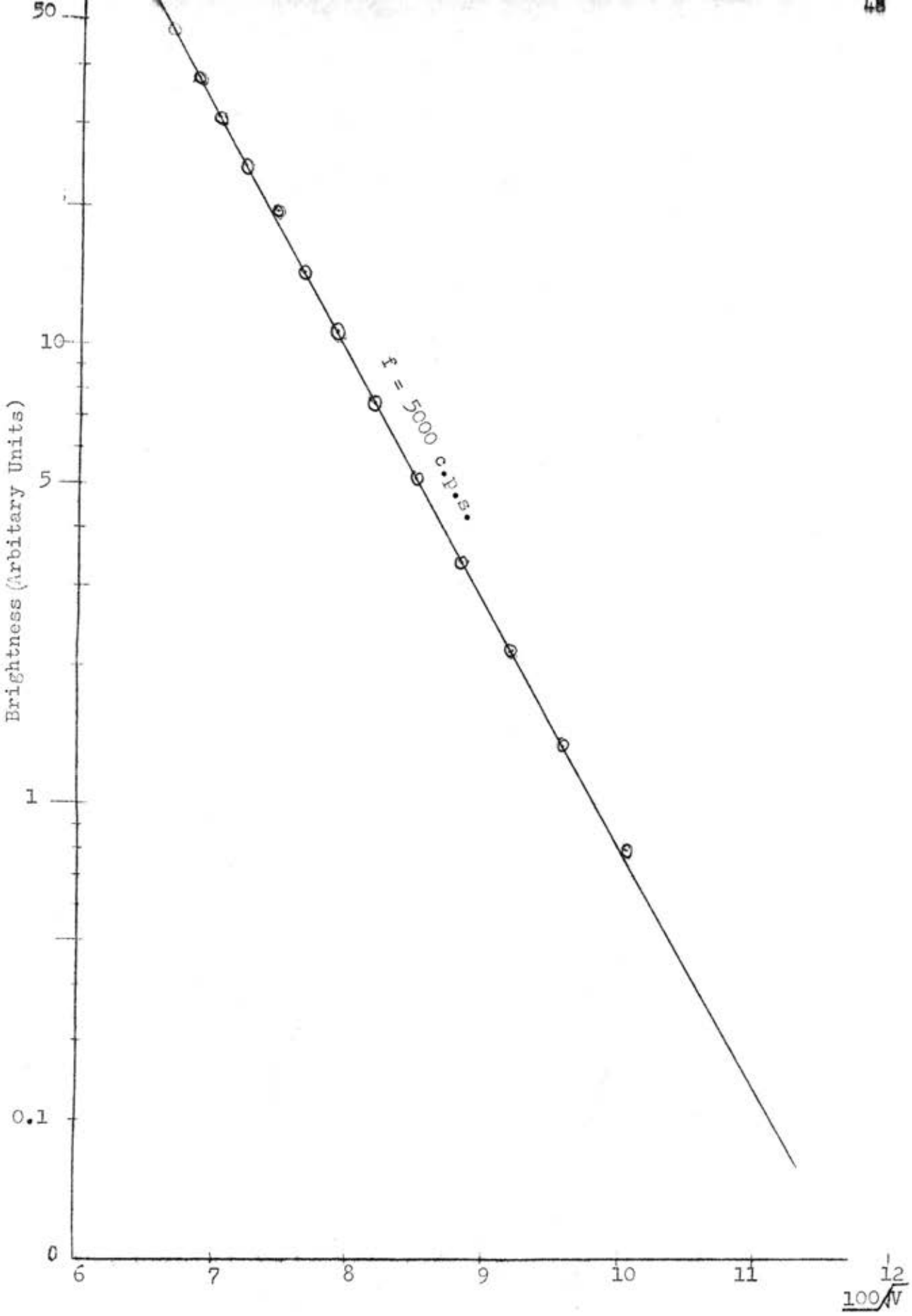


Fig. 4.8 b. Brightness Dependence on the Inverse Square Root of Voltage Applied to Electroluminescent Cell No. I at Frequency 5,000 c.p.s.

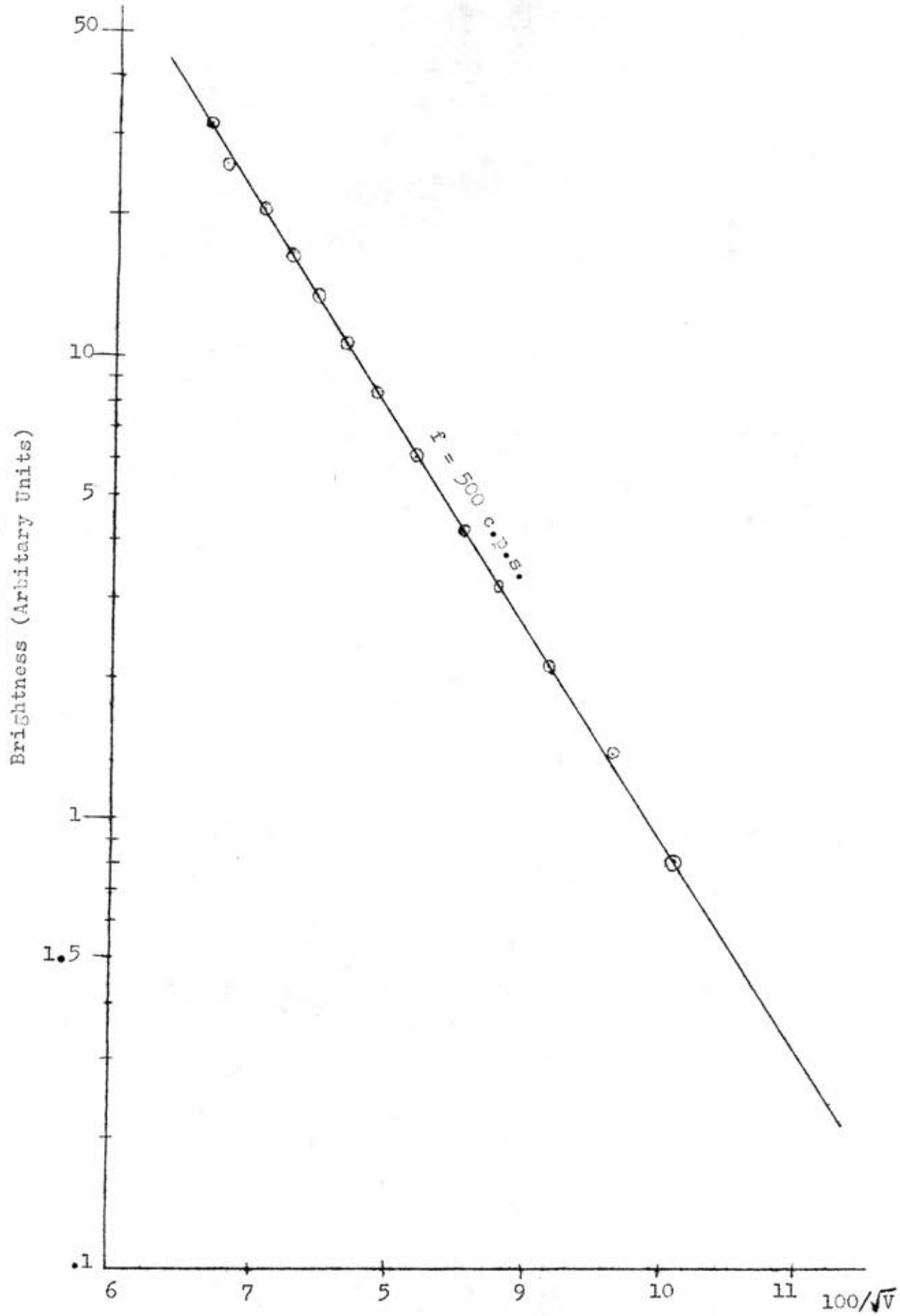


Fig. 4.8 a. Brightness Dependence on the Inverse Square Root of Voltage Applied to Electroluminescent Cell No. I at Frequency 500 c.p.s.

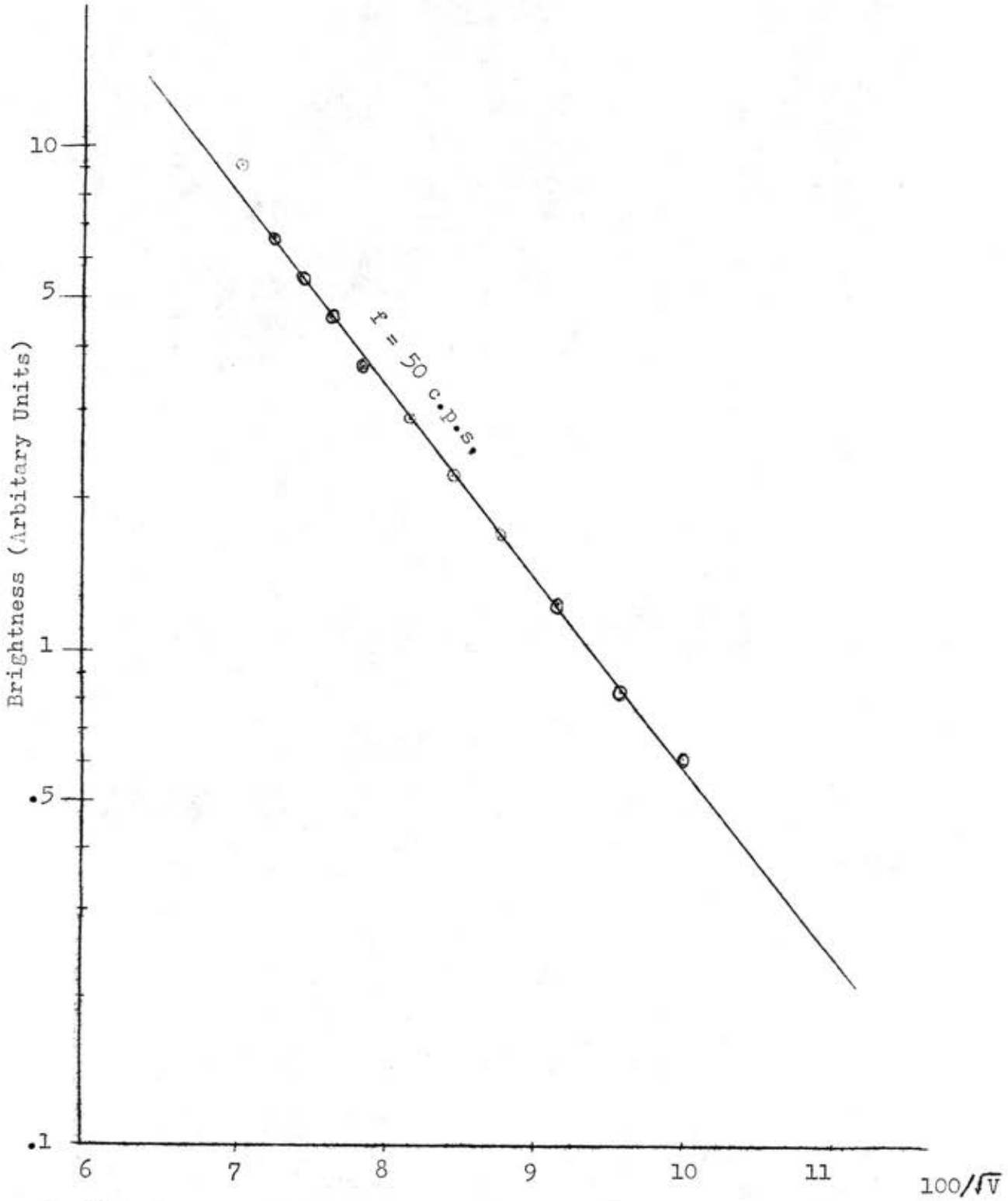


Fig.4.8 d. Brightness Dependence on the Inverse Square Root of Voltage Applied to Electroluminescent Cell No. I at Frequency 50 c.p.s.

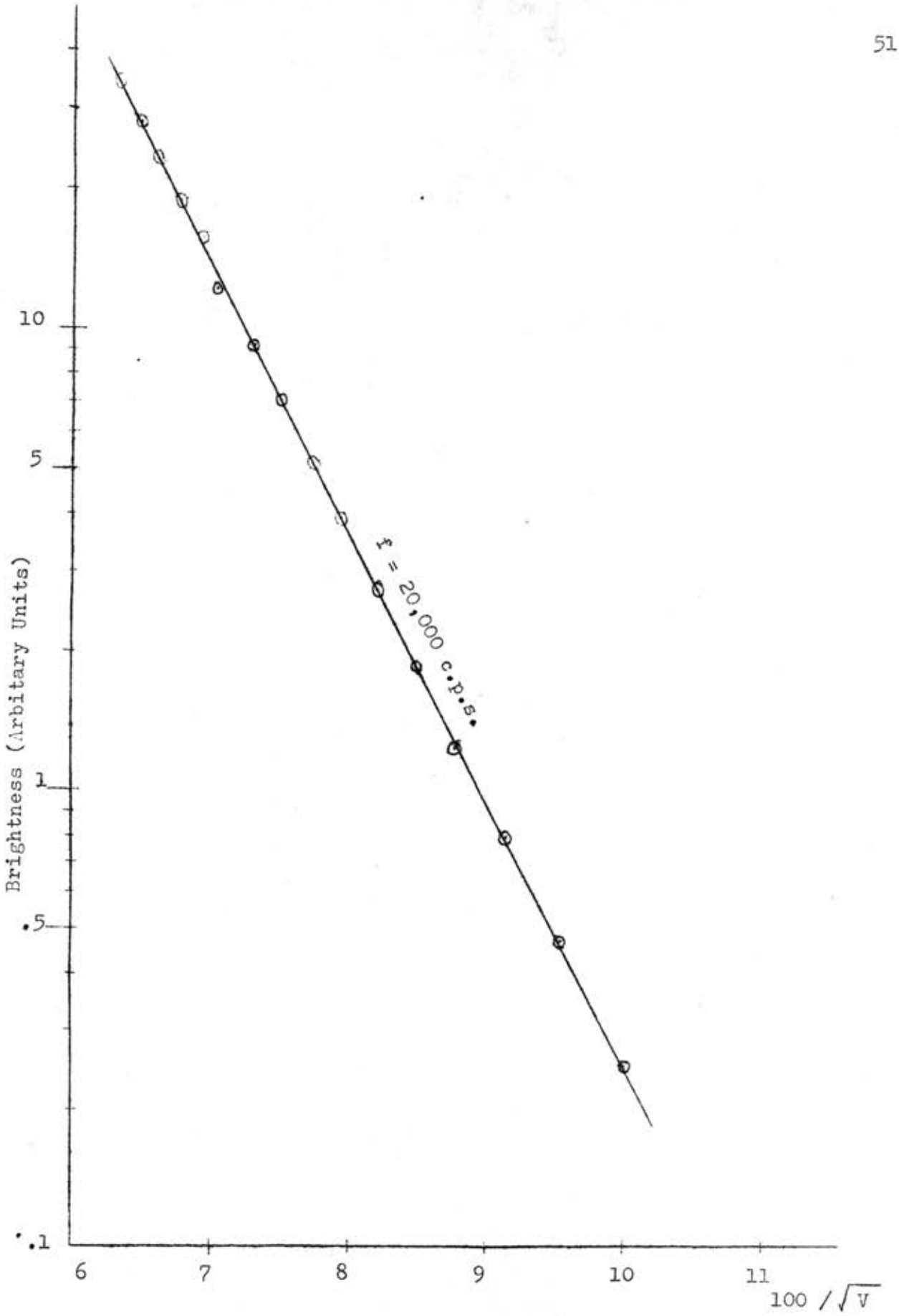


Fig. 4.9a. Brightness Dependence on the Inverse Square Root of Voltage Applied to Electroluminescent Cell No. II at Frequency 20,000 c.p.s.

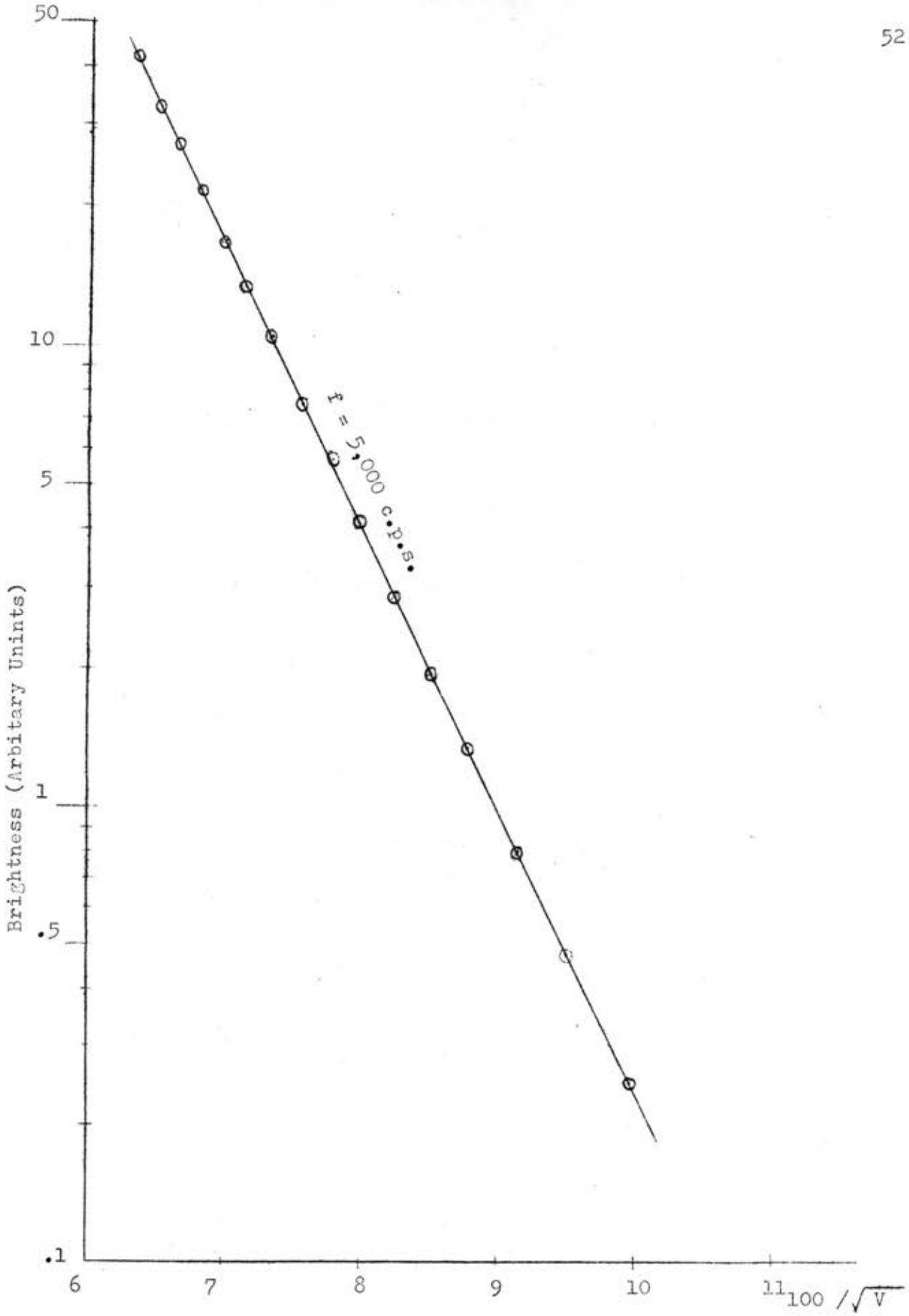


Fig. 4.9b. brightness Dependence on the Inverse Square Root of Voltage Applied to Electroluminescent Cell No. II at Frequency 5,000 c.p.s.

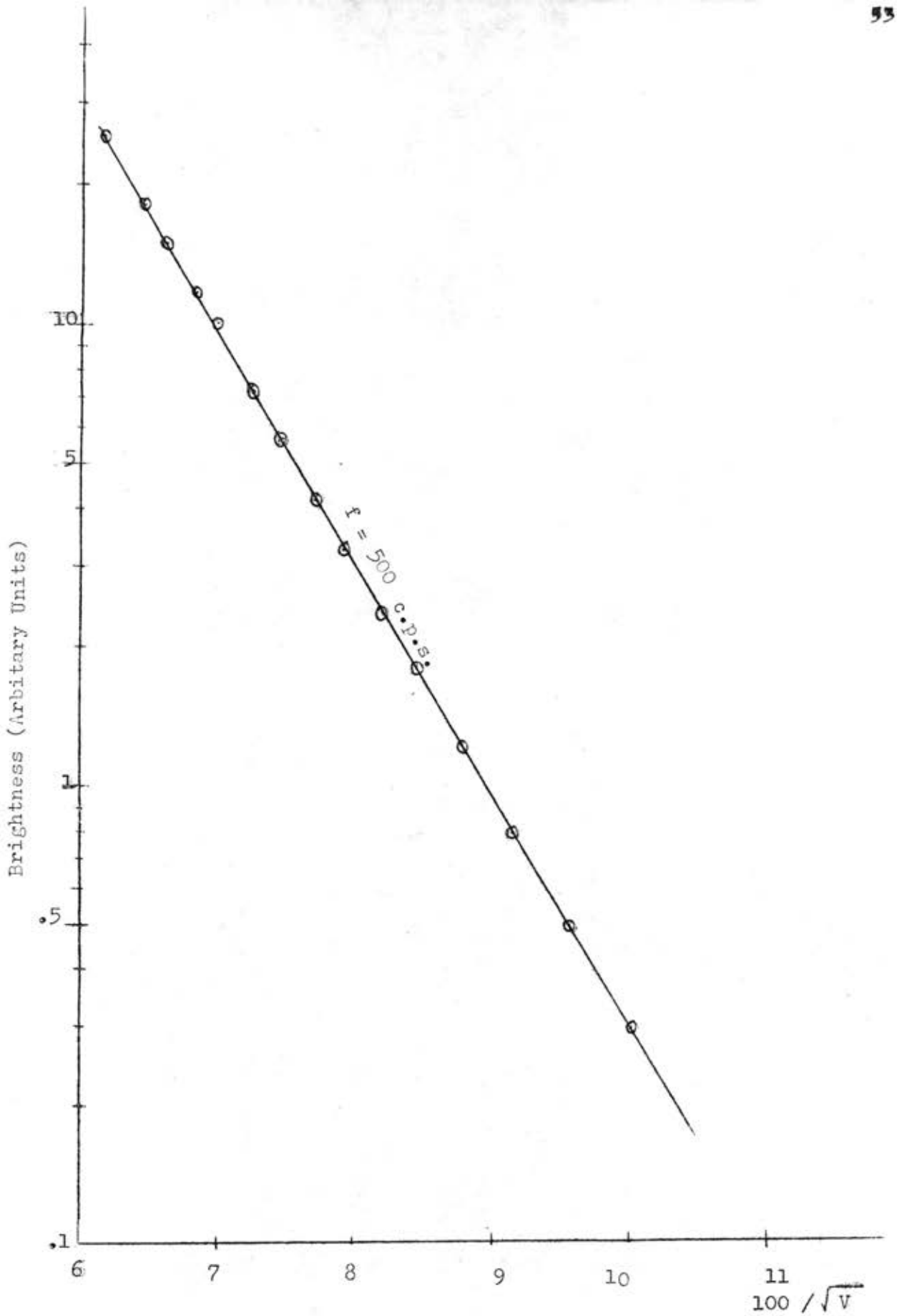


Fig. 4.9c. Brightness Dependence on the Inverse Square Root of Voltage Applied to Electroluminescent Cell No. II at Frequency 5,000 c.p.s.

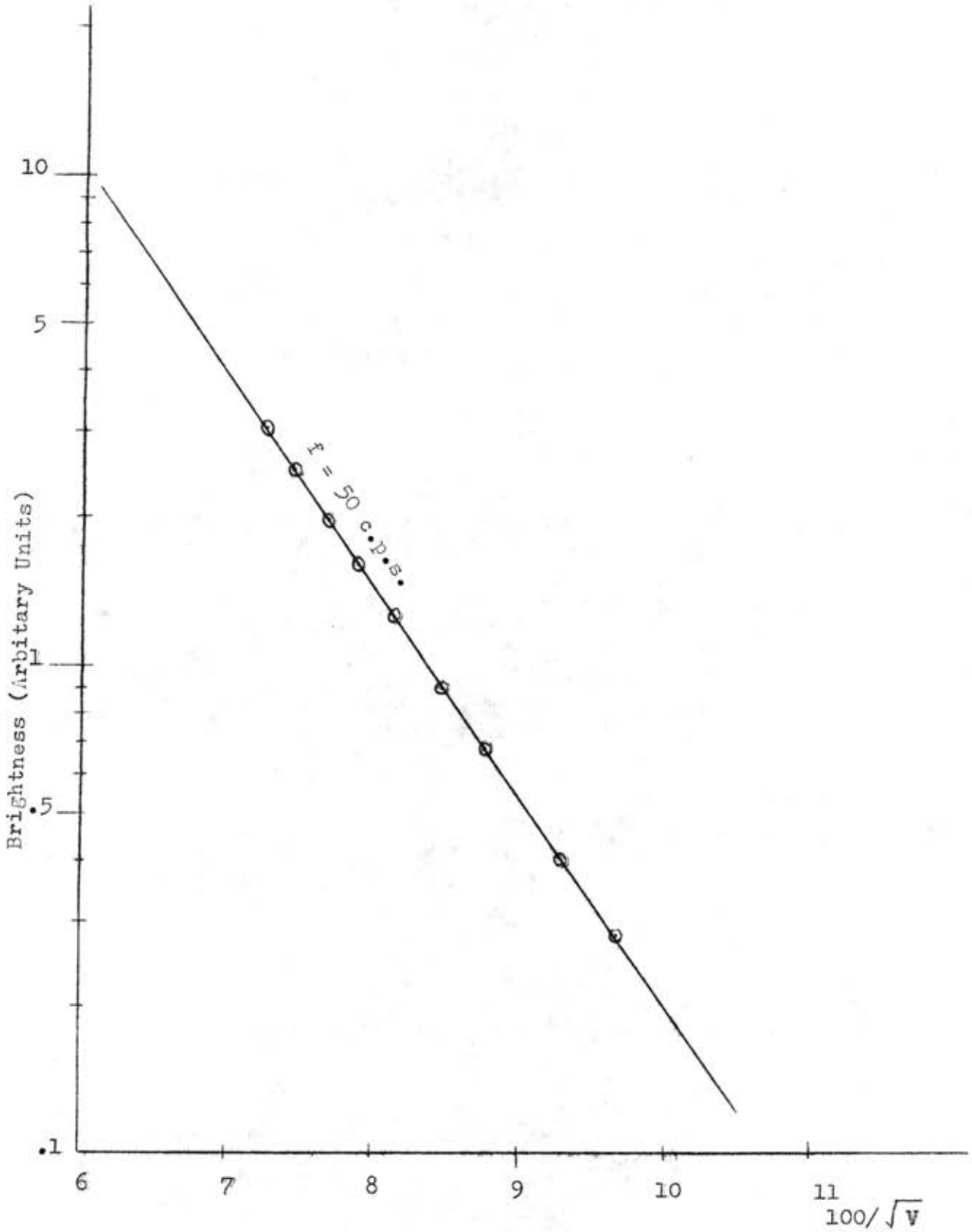


Fig. 4.9d. Brightness Dependence on the Inverse Square Root of Voltage Applied to Electroluminescent Cell No. II at Frequency 50 c.p.s.

surface of the glass plates, the stannic chloride was oxidized to stannic oxide. The sprayed surface would not be transparent if the temperature was too low. On the other hand, the plates would be broken by spraying big drops of the solution, therefore the spraying should be the one that gave very fine drops. It was found that the plates obtained by repeating a few spraying and heating were more conductive than the ones obtained by several sprayings at one time. The use of stannic oxide-coated glass plates was advantageous because it provided reasonably plane, conducting surfaces, being able to withstand relatively high voltages without shorting. Electrical connections could be clamped directly to the conducting layer without damage, thus avoiding conductivity problems.

In coating the electroluminescent phosphor on the conducting glass plate, 1:1 by volume of zinc sulfide phosphor and epoxy resin were used. The epoxy resin for the matrix was resistant to the solvents employed in the subsequent polishing procedure and exhibited excellent adherence qualities. The phosphor layer should be thick enough so that it would give the highest brightness. Electrical connections of the electrodes of the electroluminescent cell must be tightly connected to give good electrical contact. Upon applying higher voltage, the electroluminescent cell had the tendency to breakdown since the space between the electrodes was very narrow. By inserting the waxed paper, the breakdown will be resisted.

The result of the brightness produced depends on the applied A.C. voltage and frequency. There are two ways to step up its brightness: increase the voltage (i.e., strengthen the electric field) or

speed up the field's oscillating frequency. If the field is strengthened, more light emission is generated by emptying and refilling more luminescence centers in each cycle; if the frequency is increased the same result is obtained by emptying and refilling the centers more rapidly. But there are limits of both frequency and voltage dependence. Too strong a field will break down the insulating property of the phosphor layer; too short a cycle will not give the electrons time enough to emerge from their traps.